"COMPARATIVE EVALUATION OF ADDITION OF PROPOLIS OR SILVER DIAMINE FLUORIDE TO BIO-C SEALER ON REMINERALIZATION AND FRACTURRE RESISTENCE OF RADICULAR DENTIN USING AN IN-VITRO STUDY MODAL"

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In the partial fulfilment of the requirement for the degree of

MASTER OF DENTAL SURGERY

In the Speciality of

CONSERVATIVE DENTISTRY AND ENDODONTICS

BY

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INTRODUCTION

Teeth that undergo endodontic treatment may become more prone to fractures due to the loss of tooth structure during the procedure, the need for large restorations, a reduction in the amount of remaining tooth material, as well as extensive pressure while obturating and dehydration of the dentin after the treatment[1-3]. Endodontic therapy typically involves the removal of some tooth structure to access root canal and ensure thorough biomechanical preparation. The strength of a tooth that has been endodontically treated is influenced by factors such as the method used to prepare the canal and the extent of sound tooth structure that remains. The residual tooth structure, which plays a vital role in the tooth's integrity, can significantly impact the success of the treatment.[4]

Clinically, vertical root fractures are more commonly observed in teeth that have undergone endodontic treatment.[5] A vertical root fracture occurs when a root is fractured longitudinally, extending from the root canal through the dentin to the surrounding periodontal tissue. This type of fracture typically has a poor prognosis and often results in the need for tooth extraction, leaving the patient with limited restorative options.[6] The risk of vertical root fractures is compounded by various factors including the removal of tooth material during cleaning and shaping, improper obturation techniques, and excessive pressure during treatment.[6]

The primary goals of RCT include the elimination of diseased pulp tissue, biomechanical preparation the root canal system, disinfecting the canals to eliminate contaminants, and performing 3-D obturation to reduce chances of reinfection.[7,8] Obturation plays a critical role in preventing the percolation of fluids and microleakage from the periapical region into the root canal space. A properly performed obturation also prevents the possibility of reinfection, which is crucial for the long-term success of the treatment. Additionally, obturation directly influences the fracture resistance of the treated tooth by providing stability and preventing stress concentration within the tooth structure. This serves to reduce the likelihood of fractures over time.[9]

Gutta-percha combined with a sealer is considered the gold standard for obturation.[1] The sealer is essential for filling the spaces between gutta-percha cones and the space that may exist inbetween GP and the dentin canal walls. Ideal sealers should effectively seal apical and lateral

gaps within the root canal system while ensuring proper adaptation to the dentin walls.[3] Sealers with better adaptability can significantly improve the overall sealing ability, reducing the risk of reinfection and enhancing the structural integrity of the tooth post-treatment. However, extensive pressure while the cleaning and shaping stages, over-preparation, removal of posts, prior endodontic procedures, internal root resorption, or dehydration caused by irrigating solutions can all contribute to thinning and wearing down of root canal walls. These factors make the root more vulnerable to fractures under functional loads. For this reason, it is crucial to follow established guidelines meticulously when performing root canal filling to reduce the risk of fracture and preserve the long-term health of the tooth.[4,5]

Research suggests that root canal sealers that bond well to root dentin have the potential to enhance the fracture resistance of teeth that have undergone RCT.[6] The ability of these sealers to create a stronger bond with the dentin can reduce the amount of stress on the root structure, leading to a decrease in fracture occurrence. This bonding capability plays an important role in reinforcing the root, particularly in cases where a significant amount of tooth structure has been removed.[9]

One of the most significant causes of RCT failure is the development of cracks and root fractures, which often lead to tooth loss after the procedure. These cracks & fractures normally continue from canal to the outer surface of the root, penetrating through the dentin.[10] The primary cause of these fractures is tensile stress, which results from factors such as lateral compaction, stress concentration from surface depression, and the softness of the periodontal ligament. Other contributing factors include marked variations in canal anatomy which can create areas of weakness in the tooth structure. Studies conducted on single-rooted teeth have found that a little degree of curvature in canal may predispose the tooth to early cracking, as the root structure is less able to absorb the forces exerted during the treatment. As a result, clinicians have focused on methods to reinforce the residual tooth in an effort to increase the fracture resistance of RCT. Various materials and techniques, including fiber posts and resin-based restorations, have been explored to grow the strength of RCT and reduce the risk of fractures.

Dentin, the primary structural component of the tooth, consists of an organic matrix made up of 18% type I collagen, an inorganic reinforcing phase of ocrystalline carbonated apatite (70%), and

water (12%). The organic matrix is predominantly collagen (90%).[5] TDentin exhibits a hierarchical microstructure, characterized by tubules that extend outward from the pulp canal toward the cementum in root. This architecture functions as a cylindrical fiber-reinforced composite, where the intertubular dentin forms the matrix, and the tubules, along with their surrounding peritubular dentin, serve as reinforcing elements. The unique organization of dentin allows it to absorb and dissipate stress, contributing to the overall mechanical properties of the tooth.7 It has been debated whether the loss of structural integrity or changes in the properties of dentin contribute to the increased incidence of fractures following root canal treatment.8 Some studies suggest that endodontic procedures and restorative techniques may lead to changes in the mechanical properties of dentin, such as reduced elasticity and increased brittleness, making the tooth more susceptible to fractures. This further emphasizes the need for clinicians to carefully consider the effects of their treatment methods on the dentin's structural properties.

With the loss of rigidity from endodontic and restorative procedures, the potential for reinforcing the tooth becomes a critical issue. The goal of reinforcing the remaining dentin structure is not only to restore the tooth's strength but also to maintain its functional and aesthetic properties.[3] Therefore, one of the key goals of RCT is to reinforce the cut dentin, and restore both the mechanical and chemical properties of the tooth. Advanced techniques and materials are constantly being researched to improve the fracture resistance of RC treated teeth and provide better outcomes for patients, especially in cases where significant tooth structure has been removed[10].

Root fractures are a common complication in teeth that have undergone endodontic treatment and subsequent restoration.[11] Such procedures tend to increase the root's vulnerability to fracture. Therefore, the use of canal sealers that can reinforce radicular dentin has become an essential aspect of contemporary root canal therapy.[11] Various materials have been introduced for this intention, including GIC, MTA derived from Portland cement, and epoxy resin-based sealers like AH-Plus. However, many of these materials present specific clinical limitations. [12].

Silver diamine fluoride (SDF) is a transparent solution that combines the antimicrobial properties of silver with the remineralizing benefits of fluoride, making it a promising agent for the

management of dental caries, particularly in young children and individuals requiring special care. Numerous in vitro studies have demonstrated its efficacy in reducing cariogenic bacterial populations and enhancing the remineralization of both enamel and dentin. In recent years, the global adoption of SDF has grown significantly. In India, a growing number of researchers are exploring its diverse applications in dentistry, including its potential use as a pulp capping agent and as an intracanal medicament in endodontic procedures.[13]

Propolis, a natural substance produced by bees, has garnered scientific interest in the field of oral health due to its notable bioactive properties.[14] Many studies have highlighted its potential in preserving connective tissue components within the periodontium, as well as promoting healing, regeneration, and biomineralization of bone.[15]

In this study, we are trying to access remineralizing potential and fracture resistance by mixing propolis with bio-c sealer and silver diamine fluoride with bio-c sealer.

RC treated teeth are deem as weaker and prone to fracture as compared to vital teeth. There have been studies depicting the inconsistency of root to fracture and the influence of remineralizing potential of root canal sealers on radicular dentin. (11)

All these factors have lead our interest to design our study on-

AIM AND OBJECTIVES

AIM

To compare fracture resistance and remineralizing potential of Bio-C Sealer, Bio-C Sealer with silver diamine fluoride, Bio-C Sealer with propolis, and untreated teeth.

OBJECTIVES

The reason of this invitro study is to evaluate.

1. To assess the **remineralization potential and fracture resistance** of **Bio-C Sealer** in radicular dentin.
2. To evaluate and compare the **remineralization potential** of **propolis** with Bio-C Sealer and **silver diamine fluoride** with Bio-C Sealer
3. To compare **fracture resistance** of the above three groups with untreated teeth(control)

RESEARCH HYPOTHESIS

NULL HYPOTHESIS

There is no significant difference between fracture resistance and remineralizing potential by adding silver diamine fluoride and propolis in Bio-C Sealer.

ALTERNATIVE HYPOTHESIS

- Silver diamine fluoride addition to Bio-C Sealer have significant increase in fracture resistance of tooth as compared to only Bio-C Sealer due to its remineralizing potential.
- Propolis addition to Bio-C Sealer have significant increase in fracture resistance of tooth as compared to Bio-C Sealer due to its remineralizing potential.
- Silver diamine fluoride will have significant increase in fracture resistance than propolis mixed in Bio-C Sealer.

REVIEW OF LITERATURE

- **Paola Taddei , Michele Di Foggia , Fausto Zamparini , Carlo Prati and Maria Giovanna Gandolfi** published in 2023 named Guttapercha Improves In Vitro Bioactivity and Dentin Remineralization Ability of a Bioglass Containing Polydimethylsiloxane-Based Root Canal Sealer. Guttapercha (GP, trans-1,4-polyisoprene) is widely used as a root canal filling material and requires an appropriate cement, typically a polydimethylsiloxane (PDMS)-based sealer, for optimal canal obturation. This study aimed to evaluate the bioactivity and dentin remineralization potential of a bioglass-containing PDMS commercial endodontic sealer, BG-PDMS (GuttaFlow Bioseal), and to examine whether the presence of a GP cone (Roeko GP point) influences the mineralization process. To investigate this, BG-PDMS disks were aged alone or with a GP cone in Hank's Balanced Salt Solution (for 28 days at 37°C). Dentin remineralization experiments were also performed under the same conditions. Micro-Raman and IR analyses revealed that BG-PDMS is bioactive, forming a silica-rich layer that serves as a nucleation site for B-type carbonated apatite deposition. This silica layer was thicker when BG-PDMS was aged with GP. Interestingly, GP, which by itself showed no bioactivity, contributed to the nucleation of a calcium phosphate phase when aged under these conditions. Similarly, the dentin remineralization tests demonstrated that BG-PDMS promotes remineralization, particularly in the presence of GP. In this setup, GP acted as a template for calcium phosphate deposition.[2023][16]

- **Rania El-Saady Badawy, Dalia AbdAllah Mohamed** conducted a study "Evaluation of new bioceramic endodontic sealers: An in vitro study" revelead that the biophysical properties of root canal sealers (RCSs) play a crucial role in the success of endodontic treatment, as achieving an impermeable apical seal after infection eradication is essential. Bioceramic sealers, in particular, are known to release bioactive and biocompatible products post-setting, promoting chemical bonding to dentin and supporting favorable healing. This study aimed to evaluate the chemical composition and elemental distribution of four RCSs—one resin-based and three bioceramic-based—using energy dispersive X-ray spectroscopy (EDX), field emission scanning electron microscopy (FE-SEM), and elemental mapping

following root canal obturation, both coronally and apically. Forty extracted single-rooted teeth were shaped, cleaned, and randomly divided into four groups based on the sealer used. After the sealers set, the teeth were sectioned horizontally to obtain standardized coronal and apical sections, which were then assessed for chemical composition using SEM, elemental mapping, and EDX analysis. The results showed that calcium silicate sealers exhibited significantly higher calcium peaks at the root canal periphery, in contact with dentinal moisture, and higher zirconium levels, while AH Plus™ had higher tungsten levels. TotalFill® BC™, BioRoot™, and EndoSeal® MTA displayed higher calcium, oxygen, and silicon content coronally compared to apically, with phosphorus detected more apically in the latter, but differently from EndoSeal® MTA. All sealers contained trace amounts of heavy metals not listed by manufacturers, with a uniform particle distribution and nearly regular surface textures. In conclusion, all tested sealers, except AH Plus, showed high calcium/phosphorus ratio peaks, suggesting regenerative potential in vivo, with good purity, surface texture, and biocompatibility, supporting chemical bonding to root dentin.[2022][17]

- **Carolina Montoya , Yu Du, Anthony L. Gianforcaro , Santiago Orrego , Maobin Yang and Peter I. Lelkes** in a study called On the road to smart biomaterials for bone research: definitions, concepts, advances, and outlook . The growing demand for biomaterials that support the repair, replacement, or restoration of both hard and soft tissues is driven by an aging population. Historically, smart biomaterials were defined as materials that respond to external stimuli. However, the continuous advancements in the field call for a reexamination of the concept of "smartness" in biomaterials. This review offers a redefined perspective on what constitutes a “Smart Biomaterial” and highlights recent progress and applications of these materials in hard tissue restoration and regeneration. To clarify the concept of “smart biomaterials,” the review proposes four levels of smartness based on the biomaterials’ interaction with the biological environment and the cellular responses they trigger. These levels are categorized as inert, active, responsive, and autonomous. The paper further presents a comprehensive overview of the latest applications of smart biomaterials in hard tissue repair, focusing on their responses to both external and internal stimuli and their role as immunemodulatory agents. Finally, the review addresses the challenges and limitations

associated with translating basic research into clinical practice, which is essential for the development of clinically viable applications of these technologies.[2021][18]

- **Almohaimede A, Almanie D, Alaathy S, Almadi E** conducted an invitro study on Fracture Resistance of Roots Filled With Bio-Ceramic and Epoxy Resin-Based Sealers. The study aimed to assess the resistance of roots to fracture after being root canal filled with two types of endodontic sealers; bio-ceramic based sealer (TotalFill) and epoxy-resin based sealer. Fifty-nine single canal mandibular premolars were instrumented. Group I (n=14, negative control): root canals were left without instrumentation and unfilled, group II (n=15, positive control): root canals were instrumented only and left unfilled, group III and IV (n=15 each): root canals were instrumented and filled with either gutta-percha/TotalFill or gutta-percha/AH Plus, respectively. The resistance of the roots to fracture was measured with a universal testing machine "Instron Corp" through recording the maximum force in Newton (N) needed to fracture each root. To analyze the data Kruskal–Wallis test was utilized, followed by Dunn's Bonferroni post hoc test for multiple comparisons. The level of significance was set at 0.05 ($P \leq 0.05$).the study resulted in TotalFill group showed slightly better fracture resistance (734.62 N) than AH Plus group (728.29 N). However, no statistical significant difference was found between the two groups ($P > 0.05$). The greatest mean fracture force was shown in the negative control group (913.915 N) with statistical significant difference between the other three groups ($P < 0.05$). the conclusion of study was that Gutta-percha/TotalFill and gutta-percha/AH Plus did not reinforce the root canal treated teeth.[2020][19]

- **Baras B H, Melo M S , Thumbigere-Math V , Tay F R . Fouad A F, Oates T W , Weir M D , Cheng L, and Xu H. K.** conducted a review in 2007 on Novel Bioactive and Therapeutic Root Canal Sealers with Antibacterial and Remineralization Properties in which According to the American Dental Association Survey of Dental Services Rendered, 15 million root canal treatment procedures are performed annually. Endodontic therapy relies mainly on biomechanical preparation, chemical irrigation and intracanal medicaments which play an important role in eliminating bacteria in the root canal. Furthermore, adequate obturation is essential to confine any residual bacteria within the root canal and deprive them

of nutrients. However, numerous studies have shown that complete elimination of bacteria is not achieved due to the complex anatomy of the root canal system. There are several conventional antibiotic materials available in the market for endodontic use. However, the majority of these antibiotics and antiseptics provide short-term antibacterial effects, and they impose a risk of developing antibacterial resistance. The root canal is a dynamic environment, and antibacterial and antibiofilm materials with long-term effects and nonspecific mechanisms of action are highly desirable in such environments. In addition, the application of acidic solutions to the root canal wall can alter the dentin structure, resulting in a weaker and more brittle dentin. Root canal sealers with bioactive properties come in direct contact with the dentin wall and can play a positive role in bacterial elimination and strengthening of the root structure. The new generation of nanostructured, bioactive, antibacterial and remineralizing additives into polymeric resin-based root canal sealers are discussed in this review.[2020][20]

- **John Z. Reynolds ; Robert A. Augsburger ; Kathy K.H. Svoboda; and Poorya Jalali**, conducted a study named Comparing dentinal tubule penetration of conventional and 'HiFlow' bioceramic sealers with resin-based sealer: An in vitro study. This study compared the depth and percentage of dentinal tubule penetration for two obturation techniques—single-cone (SC) and warm vertical (WV)—using three different sealers: two bioceramic sealers (BC Sealer [BCS] and BC Sealer HiFlow [BCSHF]) and an epoxy resin-based sealer (2Seal easymiX). Fifty canals were filled with either BCS, BCSHF, or resin-based sealer (RBS). The BCS and BCSHF groups were filled using either SC or WV techniques, while the control group (RBS) was filled only with the WV technique. The roots were then sectioned at 3 mm and 6 mm from the apex and analyzed using a confocal laser microscope. Results showed significantly greater sealer penetration at the 6 mm level compared to the 3 mm level ($P < 0.05$). However, no statistically significant difference was observed between sealer type or obturation technique at either level ($P > 0.05$). In conclusion, dentinal tubule penetration was similar across the different sealers and obturation techniques.[2020] [21]

- **Gargouria W, Kammounb R, Elleuch M, Tlilib M, Kechaou N, Ghoul-Mazgar S** conducted a study on Effect of xylitol chewing gum enriched with propolis on dentin

remineralization invitro concluded that the Four groups of chewing gum were developed; Group1: xylitol (1.8 %), Group2: xylitol + casein phosphopeptide- amorphous calcium phosphate (CPP-ACP) (3%), Group3: xylitol+Hydroxyapatite (3%) and Group4:xylitol + propolis (5%). A control group was designed without chewing gum, but with artificial saliva. Sections of embedded crowns and cleaned roots of twenty five bovine incisors were demineralized in carbonated drink. Crown specimens were half-varnished. Remineralization process was run for all the dental specimens in the 4 groups with gum extracts and in the control group with artificial saliva for 20 min at 37 °C three times a day during 7 days. Mineral contents were evaluated by scanning electron microscopy with energy dispersive X-ray spectroscopy (EDX-SEM). Surface morphology and roughness were analyzed using atomic force microscopy. Micro-hardness was measured using Vickers micro-hardness tester among varnished and unvarnished sides.Calcium/Phosphate mean ratio showed a significant decrease between the control group, group1, group2 and group4. Control group and group3 were not significantly different. Micro-hardness increased significantly for all treated groups. AFM showed obstruction of dentinal tubules in all the groups and roughness decreased in the treated side of the dentin compared to the untreated side for tested groups.The study concluded that xylitol chewing gum enriched with propolis showed dentinal tubules occlusion, significant improvement of micro-hardness and slight decrease in roughness. [2020][22]

- **Toledano M & Muñoz-Soto E & Aguilera F. S, Osorio E & Mayra C. Pérez-Álvarez & José AD. García-Menocal & Toledano-Osorio M & Raquel Osorio** conducted a study in 2019 for The mineralizing effect of zinc oxide-modified hydroxyapatite-based sealer on radicular dentin. Cervical, medial, and apical root dentin surfaces were treated with two experimental hydroxyapatite-based cements, containing sodium hydroxide (calcypatite) or zinc oxide (oxipatite); an epoxy resin-based canal sealer, AH Plus; and gutta-percha. Remineralization, at the inner and outer zones of dentin disk surfaces, was studied by nano hardness (Hi) and Raman analysis. Nanoroughness and collagen fibrils width measurements were performed. Numerical data, at 24 h or 12 m, were analysed by ANOVA and Student-Newman-Keuls ($p < 0.05$). The result obtained from the study are that the outer and inner zones of the cervical dentin treated with oxipatite, the highest Hi after 12 m of immersion

was achieved. The same group showed the highest intensity of phosphate peak, markers for calcification and crystallinity. Nanoroughness was lower and fibril diameter was higher at the inner zone of the dentin treated with oxipatite. Dentin mineralization occurred in every region of the root dentin treated with oxipatite and calcypatite, especially at the inner zone of the dentin after 12 m. It was concluded that Oxipatite reinforced the inner root zone at any third of the radicular dentin, by increasing both nanohardness and remineralization. When using calcypatite, the highest nanohardness was found at the apical third of the inner root dentin, but the lowest mechanical performance was obtained at the cervical and the medial thirds of the roots. Therefore, application of oxipatite as sealing cement of root canals is recommended.[2019][23]

- **Ayako Washio, Takahiko Morotomi, Shinji Yoshii and Chiaki Kitamura** published a study on topic Bioactive Glass-Based Endodontic Sealer as a Promising Root Canal Filling Material Without Semisolid Core Material. Endodontic treatment for a tooth with damaged dental pulp aims to prevent and treat apical periodontitis. If the root canal is poorly obturated, leading to re-infection, periapical periodontitis can develop due to bacterial invasion. To prevent re-infection and improve the success rate of endodontic retreatment, it is essential that the treated root canal is filled three-dimensionally with a biocompatible material. Recently, bioactive glass, a type of bioceramic, has gained attention in the field of biocompatible biomaterials for endodontics. Bioactive glass-based root canal sealers have been developed and used in clinical treatments. However, there is currently limited evidence regarding patient outcomes, sealing mechanisms, sealing ability, and the removability of these sealers. In this study, we have developed a bioactive glass-based root canal sealer and provided evidence on its physicochemical properties, biocompatibility, sealing ability, and removability. We also review the classification of bioceramics and the characteristics of bioactive glass. Additionally, we discuss how bioactive glass can aid in the development of a new root canal sealer and explore the potential use of bioactive glass-based cement as a root canal filling material in the absence of a semisolid core material.[2019][24]

- **Lin Wang , Xianju Xie, Chunyan Li , Huaibing Liu , Ke Zhang , Yanmin Zhou , Xiaofeng Chang** in a study named Novel bioactive root canal sealer to inhibit endodontic

multispecies biofilms with remineralizing calcium phosphate ions. In this study, a bioactive endodontic sealer was developed for the first time using dimethylaminohexadecyl methacrylate (DMAHDM), 2-methacryloyloxyethyl phosphorylcholine (MPC), and nanoparticles of amorphous calcium phosphate (NACP). The objectives were to evaluate the sealer's effectiveness in inhibiting early-stage and mature multispecies endodontic biofilms, its bond strength to root canal dentin, and its release of calcium (Ca) and phosphate (P) ions. A series of bioactive endodontic sealers were formulated with DMAHDM, MPC, and NACP, and root dentin bond strength was assessed using a push-out test. Biofilms of three endodontic strains—E. faecalis, A. naeslundii, and F. nucleatum—were grown on the sealer disks for 3 days (early-stage) and 14 days (mature-stage). Colony-forming units (CFU), live/dead assay, metabolic activity, and polysaccharide content were measured, and the release of Ca and P ions from the sealer was quantified. The results showed that incorporating DMAHDM, MPC, and NACP did not reduce the push-out bond strength ($p > 0.1$). The addition of DMAHDM and MPC reduced biofilm CFU by 3 log, with both DMAHDM and MPC significantly lowering the CFU ($p < 0.05$). The combination of DMAHDM + MPC exhibited greater biofilm-killing efficacy than either DMAHDM or MPC alone ($p < 0.05$). Additionally, the sealer with DMAHDM + MPC released slightly fewer, but not significantly fewer, Ca and P ions compared to the sealer without DMAHDM + MPC ($p > 0.1$). In conclusion, a novel bioactive endodontic sealer was developed that significantly inhibited multispecies endodontic biofilms, reduced biofilm CFU by 3 log, incorporated NACP for remineralization, and demonstrated strong bond strength to root canal dentin.[2019][25]

- **Yasmi O. Crystal, DMD, MSc** conducted a review on Evidence-Based Dentistry Update on Silver Diamine Fluoride concluded that current evidence on the effectiveness of silver diamine fluoride (SDF) as a caries arresting and preventive agent. It provides clinical recommendations around SDF's appropriate use as part of a comprehensive caries management program. Systematic reviews confirm that SDF is effective for caries arrest on cavitated lesions in primary teeth and root caries in the elderly. It may also prevent new lesions. Application is easy, noninvasive, affordable, and safe. Although it stains the lesions

dark as it arrests them, it provides clinicians with an additional tool for caries management when esthetics are not a primary concern.[2018][26]

- **Khine W. Zan , Keiki Nakamura , Hidenori Hamba, Alireza Sadr , Toru Nikaido , Junji Tagami** stated in a study named Micro-computed tomography assessment of root dentin around fluoride-releasing restorations after demineralization/remineralization that micro-computed tomography (micro-CT) was used to evaluate the inhibitory effects of three different types of restorations on root caries formation under a cariogenic challenge. Bovine root dentin blocks with cylindrical cavities were divided into three restoration groups: a fluoride-free self-etch adhesive with resin composite (SE-ES), a self-etch adhesive with resin composite and multi-ion release (FL-BF), and glass ionomer cement (Fuji-VII). After the restorative procedures, the specimens were stored in artificial saliva for 1 day, followed by exposure to a demineralization solution for 4 days and a remineralization solution for 28 days. Micro-CT was used to measure mineral density and mean mineral loss in the dentin around the restorations. The highest mean mineral loss was observed with SE-ES restorations, while Fuji-VII restorations showed the lowest mineral loss. Fuji-VII also exhibited the highest mineral density and the least mineral loss after 28 days of remineralization. Scanning electron microscopy images revealed that Fuji-VII created the smallest outer lesion, followed by FL-BF and SE-ES. The results suggest that Fuji-VII has the strongest inhibitory effect on root caries around restorations and promotes remineralization more effectively than FL-BF or SE-ES. The release of multi-ions and fluoride from the restorative materials may contribute to the inhibition of root dentin caries around the restorations.[2018][27]

- **Dibaji F , Afkhami F , Bidkhori B , Kharazifard M J** conducted a study on Fracture Resistance of Roots after Application of Different Sealer. Cervical and apical root dentin surfaces were treated with two experimental hydroxyapatite-based sealers, containing sodium hydroxide (calcypatite) or zinc oxide (oxi-patite) and an epoxy resin-based canal sealer (AH Plus); gutta-percha without sealer was included as control. Dentin surfaces were studied by X-ray diffraction and transmissionelectron microscopy through selected area diffraction and bright-field imaging after 24 hand 12 m of storage. Root cervical dentin treated with

calcypatite and oxipatite produced poor crystallinity of new minerals, wide amorphous phase and non-stoichiometry. Reflections at the 002 plane and the corresponding diffraction rings attained lower values in the Scherrer equation and the Scherrer-Wilson equation in samples treated with both HAp-based sealers than in specimens without sealer or with AH Plus. At root cervical dentin treated with calcypatite, shorter and wider crystallite size formations and lower crystals grain size were found,if compared to those encountered at oxipatite treated dentin. Oxipatite attained improved crystallographic atomic order and less structural variation in both distances and angles. Apical dentin treated with oxipatite attained preferred grain orientation with polycrystalline lattices.[2017][28]

- **Khallaf M E** did a study on Effect of two contemporary root canal sealers on root canal dentin microhardness. The aim of this study was to evaluate and compare the effect of two root canal sealers on dentin microhardness. Four way-ANOVA revealed that different tested sealer materials, canal third, measuring distance from the pulp and time as independent variables had statistically non significant effect on mean microhardness values (VHN) at $p \leq 0.001$. Among iRoot SP groups there was a statistically significant difference between iRoot SP at coronal root portion (87.79±17.83) and iRoot SP at apical root portion (76.26±9.33) groups where (p=0.01). I Root SP at coronal canal third had higher statistically significant mean microhardness value (87.79±17.83) compared to Apexit at coronal third (73.61±13.47) where (p=0.01). the conclusion of the study was that the root canal sealers do not affect dentin microhardness.[2017][29]

- **Xiao S, Liang K, Weir MD, Cheng L, Liu H, Zhou X, Ding Y, Xu HHK** conducted a study in 2017 on Combining Bioactive Multifunctional Dental Composite with PAMAM for Root Dentin Remineralization. They prepared and demineralized root dentin samples with 37% phosphoric acid for 15 s. Four groups were prepared: (1) root dentin control; (2) root dentin with BMC; (3) root dentin with PAMAM; (4) root dentin with BMC + PAMAM. Specimens were treated with a cyclic artificial saliva/lactic acid regimen for 21 days. Calcium (Ca) and phosphate (P) ion concentrations and acid neutralization were determined. The remineralized root dentin specimens were examined via hardness testing and scanning electron microscopy (SEM).tthey concluded that there was excellent root dentin

remineralization effects of BMC + PAMAM were demonstrated for the first time. BMC + PAMAM induced effective and complete root dentin remineralization in an acid challenge environment. The novel BMC + PAMAM method is promising for Class V and other restorations to remineralize and protect tooth structures.[2016][30]

- **Afaf AL-Haddad and Zeti A. Che Ab Aziz** conducted a research for review article in 2016 named Bioceramic-Based Root Canal Sealers: A Review stated that Bioceramic-based root canal sealers are recognized as a promising advancement in endodontics. This review aimed to examine both laboratory experiments and clinical studies involving these sealers. A thorough search of the endodontic literature was conducted to identify relevant publications on bioceramic-based root canal sealers. The review assessed the findings of laboratory and clinical studies regarding the biological and physical properties of these sealers, as well as comparisons with other types of sealers. Various studies were evaluated, covering aspects such as physical properties, biocompatibility, sealing ability, adhesion, solubility, and antibacterial effectiveness. The results indicated that bioceramic-based sealers are biocompatible and perform similarly to other commercial sealers. However, clinical outcomes related to the use of bioceramic-based root canal sealers remain inconclusive in the existing literature.[2016][31]

- **Luciano Tavares Angelo Cintra, Francine Benetti, Índia Olinta de Azevedo Queiroz, Luciana Louzada Ferreira, Loiane Massunari, Carlos Roberto Emerenciano Bueno, Sandra Helena Penha de Oliveira, João Eduardo Gomes-Filho**, stated that This study assessed the cytotoxicity and biocompatibility of a new bioceramic endodontic sealer, Sealer Plus BC, in comparison to MTA Fillapex and AH Plus. L929 fibroblasts were cultured, and Alamar Blue was used to evaluate cell viability for diluted extracts (1:50, 1:100, and 1:200) from each sealer after 24 hours. Polyethylene tubes filled with the materials or left empty (control) were implanted in the subcutaneous tissue of rats. After 7 and 30 days, the rats (n = 8) were euthanized, and the tubes were removed for histological examination. Parametric data were analyzed using a one-way ANOVA, while nonparametric data were analyzed using the Kruskal–Wallis test followed by the Dunn test ($p < 0.05$). A decrease in cell viability was observed with more diluted extracts of Sealer Plus BC compared to the Control and AH Plus

($p < 0.05$), although the 1:50 dilution of Sealer Plus BC was similar to the Control ($p > 0.05$). In contrast, more diluted extracts of MTA Fillapex (1:200) and AH Plus (1:100 and 1:200) showed no significant difference from the Control ($p > 0.05$). Histological analysis at 7 days revealed no significant differences in tissue response between the materials, with a thick fibrous capsule observed ($p > 0.05$). After 30 days, Sealer Plus BC was comparable to the Control ($p > 0.05$), while MTA Fillapex and AH Plus exhibited more inflammation than the Control ($p < 0.05$). The fibrous capsule was thinner in the Control and most specimens of Sealer Plus BC and AH Plus. Overall, Sealer Plus BC showed biocompatibility similar to MTA Fillapex and AH Plus, and exhibited lower cytotoxicity with less-diluted extracts.[2016][32]

- **Gaurav Setya, Ajay Nagpal , Sunil Kumar , Navin Anand Ingle** conducted a study on Comparison of root canal sealer distribution in obturated root canal: An in-vitro study. This study aimed to compare the distribution of sealer in root canals using three different sealers and three different obturation techniques. AH Plus, Fuji-1, and Tubliseal Extended Working Time (EWT) sealers were placed into the prepared root canals of 90 maxillary central incisors using a lentulospiral. The canals were then obturated using three different gutta-percha filling techniques: single cone, lateral condensation, and vertical condensation. Horizontal sectioning was performed at 3 mm and 6 mm from the apex using a diamond disk, and the two resulting specimens were examined for sealer distribution with a stereomicroscope. The percentage of sealer coating the perimeter (PSCP) was calculated using a digital imaging system. The results revealed a significant difference in the mean PSCP values among the three sealers ($P < 0.000$), with Tubliseal EWT showing the highest PSCP values, followed by AH Plus and Fuji-1. Differences were also observed between the obturation techniques ($P < 0.000$), with the single cone technique yielding the highest mean PSCP values, followed by lateral condensation and vertical condensation. No significant difference was found between the 3 mm and 6 mm sections ($P < 0.945$). In conclusion, Tubliseal EWT demonstrated the highest PSCP value, while the single cone technique produced the highest PSCP values compared to lateral and vertical condensation techniques at both the 3 mm and 6 mm sections.[2014][33]

- **Üstün Y, Arslan S, Aslan T**. conducted a study in 2013 on the effects of calcium hydroxide and propolis intracanal medicaments on bond strength of resin-based endodontic sealer as assessed by push-out test. The aim of this study was to investigate the effects of calcium hydroxide (Ca(OH)2) and propolis intracanal medicaments on bond strength of AH Plus to root dentin. After chemomechanical instrumentation using Revo-S rotary system, three groups of root canal specimens were prepared: 10 root canals were left untreated as controls (G1), 10 received Ca(OH)2 intracanal medicament (G2), and another 10 received propolis intracanal medicament (G3). Canals were obturated with AH Plus and gutta-percha. After bond strength evaluation using micro push-out test, data were analyzed using ANOVA and Tamhane's test ($p=0.05$). At coronal and middle thirds, there were no significant differences in bond strength among the three groups ($p>0.05$). At apical third, G3 was significantly superior to G2 ($p<0.05$) and G1 ($p<0.05$), but there was no significant difference between G2 and G1 ($p>0.05$). Therefore, when AH Plus was used as the sealer in endodontic treatments, its combined use with propolis as an intracanal medicament seemed to result in favorable sealer-dentin interfacial bond strength.[2013][34]

- **Toledano-Osorioa M, Aguileraa F, Osorioa, , Mu˜noz-Sotoa E, Pérez-Álvarezb M C, López-Lópezc, Lynchd C, Toledano M** conducted a study on Hydroxyapatite-based cements induce differentapatite formation in radicular dentin .Root cervical dentin treated with calcypatite and oxipatite produced poor crys-tallinity of new minerals, wide amorphous phase and non-stoichiometry. Reflections at the 002 plane and the corresponding diffraction rings attained lower values in the Scherrerequation and the Scherrer-Wilson equation in samples treated with both HAp-based sealersthan in specimens without sealer or with AH Plus. At root cervical dentin treated with calcy-patite, shorter and wider crystallite size formations and lower crystals grain size were found,if compared to those encountered at oxipatite treated dentin. Oxipatite attained improvedcrystallographic atomic order and less structural variation in both distances and angles. Api-cal dentin treated with oxipatite attained preferred grain orientation with polycrystallinelattices.[2010][35]

- **Mahmoud Khaled Al-Omiri, Ahmad Abdelaziz Mahmoud, Mohammad Ramadan Rayyan, and Osama Abu-Hammad"Fracture Resistance of Teeth Restored with Post-Retained Restorations: An Overview"**This article reviews the factors influencing the fracture resistance of teeth restored with post-retained restorations. A systematic review of studies from PubMed/MEDLINE, Cochrane, and Scopus (1960–2010) was conducted, including in vivo and ex vivo investigations. The review found that fracture resistance is influenced by factors such as the extent of tooth structure loss, the presence of a ferrule, the use of posts with properties similar to natural dentin, and adhesive techniques for post luting and coronal restoration. Adhesively luted resin/fiber posts with composite cores were identified as the best option for optimizing tooth fracture resistance and biomechanical behavior. The study highlights the need for more long-term, controlled clinical studies to form definitive conclusions on the role of endodontic posts.[36]

- **Tay and Pashley** explored biomimetic remineralization of resin-bonded, acid-etched dentin using a system containing Portland cement and simulated body fluid with polymeric analogs. They found that both intrafibrillar and interfibrillar apatite formation occurred within hybrid layers after 2–4 months, and apatite clusters also formed within the resin matrix. These results suggest that biomimetic strategies can effectively remineralize incompletely infiltrated resin-dentin interfaces and potentially enhance bond longevity.[37]

- **Li-sha Gu, Bradford P. Huffman, Dwayne D. Arola, Young Kyung Kim, Sui Mai, Mohammed E. Elsalanty, David H. Pashley, and Franklin R. Tay"**Changes in Stiffness of Resin-infiltrated Demineralized Dentin after Remineralization with a Bottom-up Biomimetic Approach"This study explored how biomimetic remineralization affects the stiffness, mineral content, and structure of resin-infiltrated demineralized dentin. Sixty dentin beams treated with three different adhesives were first soaked in simulated body fluid (SBF) to establish baseline stiffness. Half were then placed in a biomimetic remineralization medium, while the rest remained in SBF as controls. Over 15 weeks, the remineralized samples showed a 55–118% increase in stiffness, while controls remained unchanged. Imaging confirmed new mineral formation both on the surface and within the dentin,

including intra- and interfibrillar regions. The process occurred without relying on residual mineralized dentin, driven by diffusion of nanoprecursors and biomimetic agents.[38]

- **M Karapinar Kazandag, H Sunay, J Tanalp, and G Bayirli**"Fracture Resistance of Roots Using Different Canal Filling Systems**"**This study aimed to evaluate the fracture resistance of teeth filled with various canal filling materials. One hundred single-rooted teeth were shaped using Endo-Sequence files and divided into six groups, with different filling systems: Group 1 (AH-Plus + Gutta-percha), Group 2 (Resilon + Epiphany), Group 3 (ActiV GP cone + ActiV GP sealer), Group 4 (ActiV GP sealer + Gutta-percha), Group 5 (no instrumentation or filling), and Group 6 (instrumented but unfilled). After filling and setting, the teeth were subjected to compressive loading, and the fracture resistance was recorded. The results showed that teeth filled with AH-Plus + Gutta-percha exhibited significantly higher fracture resistance than those filled with ActiV GP sealer + Gutta-percha. Systems designed to create a monoblock system did not offer superior fracture resistance compared to the conventional AH-Plus + Gutta-percha method.[39]

- **Sui Mai, Young Kyung Kim, Manuel Toledano, Lorenzo Breschi, Jun Qi Ling, David H. Pashley, and Franklin R. Tay"Phosphoric Acid Esters Cannot Replace Polyvinylphosphonic Acid as Phosphoprotein Analogs in Biomimetic Remineralization of Resin-Bonded Dentin"**This study investigated whether phosphoric acid esters found in dental adhesives could substitute polyvinylphosphonic acid (PVPA) as phosphoprotein analogs in biomimetic remineralization of resin-dentin interfaces. Human dentin was bonded using three adhesives and immersed in different remineralization media: a control (no analog), a medium with polyacrylic acid (PAA) only, and a medium with both PAA and PVPA. No remineralization was observed in the control, and only minimal or non-intrafibrillar crystal formation occurred with PAA alone. Intrafibrillar remineralization was achieved only with the dual-analog medium containing PVPA. The results confirm that phosphoric acid esters cannot replace PVPA in supporting effective biomimetic remineralization.[40]

- **Jones Mathias, S. Kavitha, and S. Mahalaxmi "A Comparison of Surface Roughness after Micro Abrasion of Enamel with and without using CPP-ACP: An In Vitro Study"**This in vitro study evaluated how the application of CPP-ACP (Casein Phosphopeptide-Amorphous Calcium Phosphate) affects enamel surface roughness following micro abrasion. Thirty extracted anterior teeth were divided into three groups: Group A underwent only micro abrasion, Group B received CPP-ACP daily for 30 days after micro abrasion, and Group C served as an untreated control. Surface roughness was measured after 30 days using a profilometer. Results showed that combining CPP-ACP with micro abrasion significantly reduced enamel roughness compared to micro abrasion alone, suggesting a lower risk of caries with CPP-ACP use.[41]

METHODOLOGY

STUDY SETTING AND DESIGN

- The study will be conducted in the Department of Conservative Dentistry and Endodontics, Santosh Dental College and Hospital, Ghaziabad.
- In- vitro study design

ETHICAL CONSIDERATION

The present study will be conducted as per the ethical principles laid by screening committee in detail by the Institution Ethics Committee of Santosh Deemed to be University, Ghaziabad. The informed consent will be obtained from the patients of all study subjects prior to inclusion in the study.

SAMPLE SIZE CALCULATIONS

The sample size was calculated using openEpi statistical services . the power of the study 80% and confidence interval (C.I) OF 95% was taken. The sample size was estimated to be 23 samples per group by comparing two means.

Sample Size For Comparing Two Means

Input Data

Confidence Interval (2-sided)	95%
Power	80%
Ratio of sample size (Group 2/Group 1)	1

	Group 1	Group 2	Difference*
Mean	913.91	728.29	185.62
Standard deviation	187.3	193.2	
Variance	35081.3	37326.2	

Sample size of Group 1	17
Sample size of Group 2	17
Total sample size	34

*Difference between the means

Results from OpenEpi, Version 3, open source calculator--SSMean
Print from the browser with ctrl-P
or select text to copy and paste to other programs.

CRITERIA FOR CASE SELECTION

INCLUSION CRITERIA

- Human teeth with a single root
- Teeth with a single root canal, confirmed by pre-operative radiographs in both buccolingual and mesiodistal directions.
- Teeth without visible caries, internal or external root resorption, or severe structural damage.
- Teeth that can be decoronated to yield a 13-mm-long root.

EXCLUSION CRITERIA

- Teeth with more than one root canal or with incomplete formation of apices.
- Teeth with severe curvature, dilacerated roots, or abnormal root morphology.
- Teeth with a history of prior root canal treatment.
- Teeth with calcifications, fractures, or any signs of significant pathology..
- Teeth with visible caries or signs of active decay.

SAMPLE GROUP

Selected teeth were divided into 2 main groups with one group with 4 teeth and other with 68

Group 1:4 teeth

Group 1A: Normal/untreated teeth [n=1]

Group 1B: Bio C Sealer [n=1]

Group 1C: Bio C Sealer + Silver Diamine Fluoride[n=1]

Group 1D: Bio C Sealer + Propolis[n=1]

Group 2: 68 teeth

Group 2A: Normal/untreated teeth [n=17]

Group 2B: Bio C Sealer [n=17]

Group 2C: Bio C Sealer + Silver Diamine Fluoride[n=17]

Group 2D: Bio C Sealer + Propolis[n=17]

ARMAMENTARIUM AND MATERIALS

- Airrotor
- Round burs
- K files
- Zen flex files
- Silver diamine fluoride
- Propolis
- Bio-C-Sealer
- Saline
- Sodium Hypochlorite
- Syringe
- Juldent saw disc
- PBS solution
- Ethanol
- Lentulospiral
- Vernier calliper

FIGURE 1: PROPOLIS

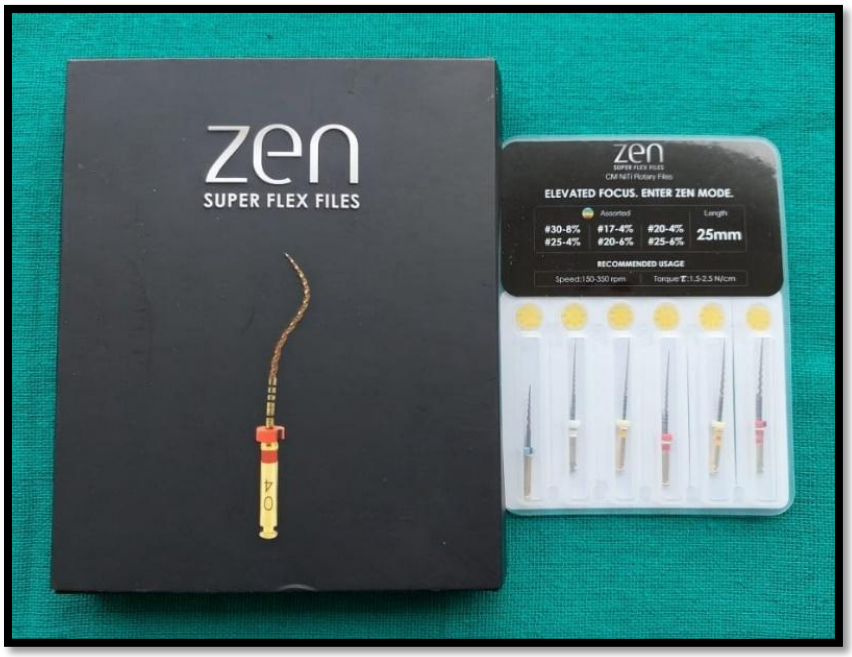


FIGURE 2: ZEN FLEX FILES

FIGURE 3: BIO-C SEALER

FIGURE 4: SILVER DIAMINE FLUORIDE

FIGURE 5: MOUTH MIRROR, EXPLORER, TWEEZER

FIGURE 6: MASK AND GLOVES

FIGURE 7 : MICROMOTOR (MARATHON) AND HANDPIECE (NSK) FOR DECORONATION

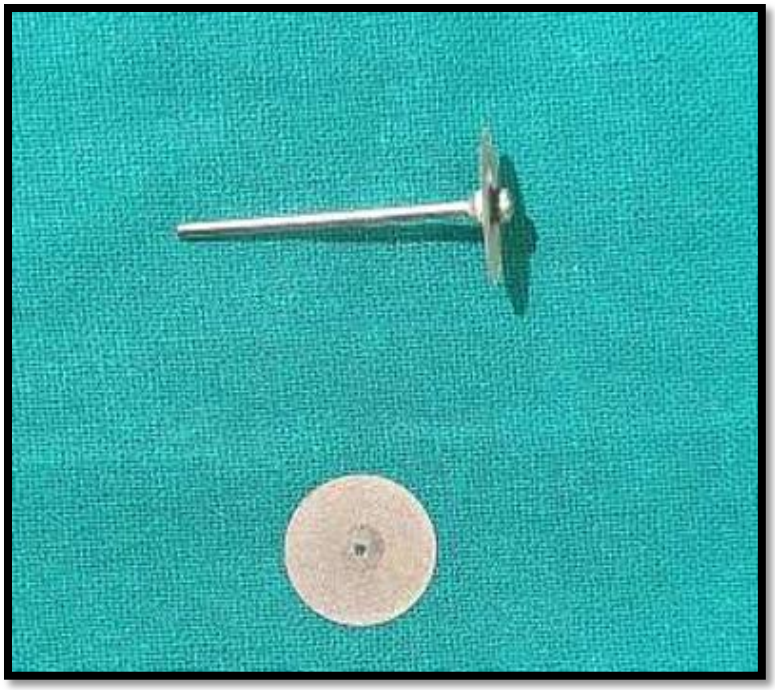


FIGURE 8: DIAMOND DISC (DENTARUM) FOR DECORONATION

FIGURE 9 : SIDE VENTED NEEDLE AND DISPOSABLE SYRINGES FOR IRRIGATION

FIGURE 10: 25% GLUTARALDEHYDE SOLUTION AND PHOSPHATE BUFFER SOLUTION

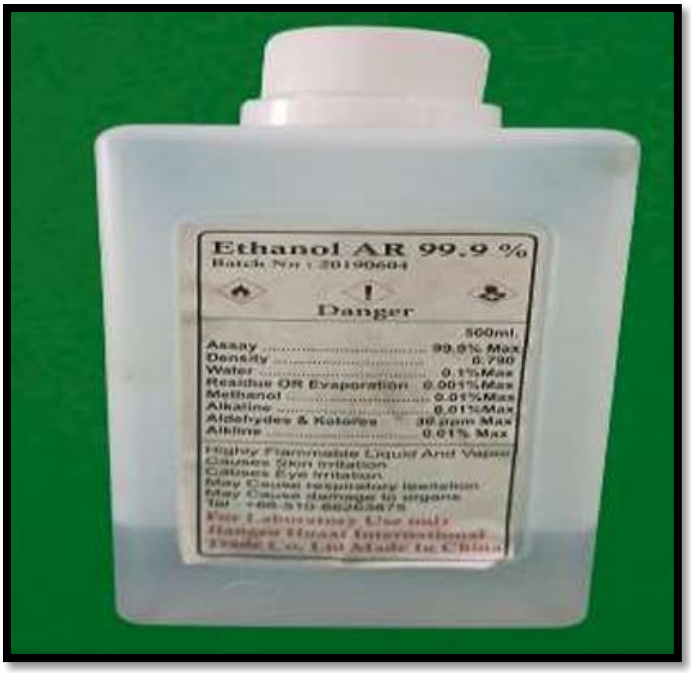


FIGURE 11: ETHANOL

FIGURE 12: SALINE

FIGURE 13: LIQUID EDTA

FIGURE 14: PLOYVINYLSILOXANE IMPRESSION MATERIAL

FIGURE 15: K FILES

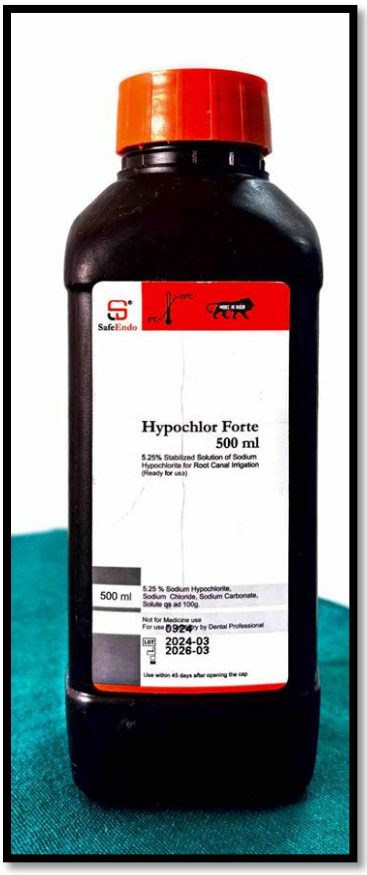


FIGURE 16: SODIUM HYPOCHORITE

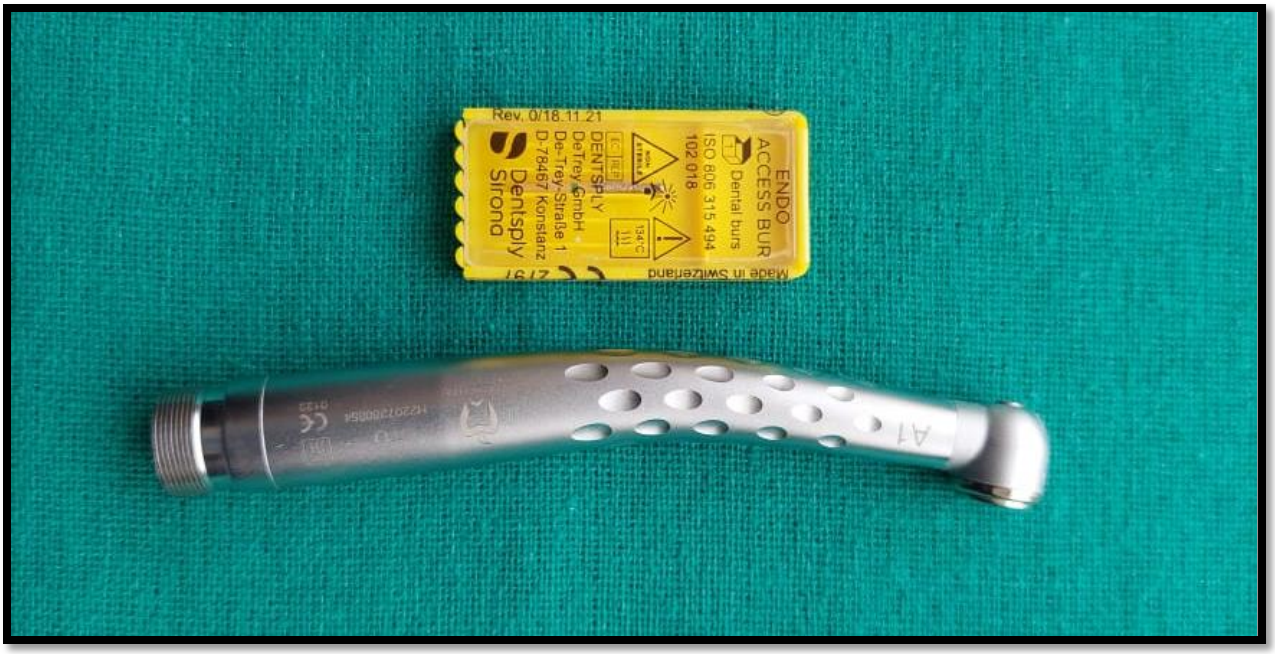


FIGURE 17: AIRROTOR WITH BURS

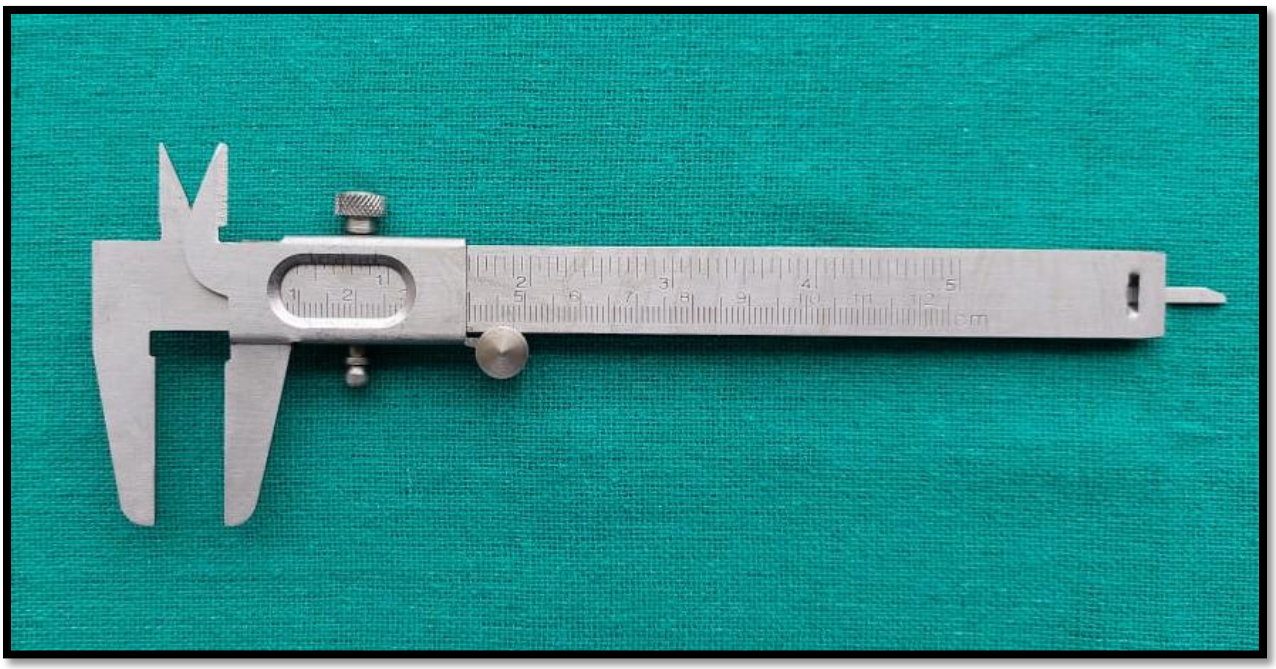


FIGURE 18: VERNEIR CALLIPER

FIGURE 19: SILVER SPUTTERING MACHINE

FIGURE 20: SCANNING ELECTRON MICROSCOPE[SEM]

FIGURE 21: UNIVERSAL TESTING MACHINE FOR MEASURING FRACTURE RESISTANCE

PROCEDURE

Teeth with single roots were selected for the study and stored in a 0.1% thymol solution. Pre-operative radiographs were obtained in both buccolingual and mesiodistal orientations to confirm the presence of a single canal. Teeth exhibiting calcifications, fractures, immature apices, previous endodontic treatment, or canals larger than a #25 K-file were excluded. Additionally, specimens with significant root curvature, dilaceration, internal or external resorption, or dental caries were omitted.[42]

The coronal part of teeth were removed using a straight fissure diamond bur under continuous water cooling, standardizing root length to 13 mm. Working length was recorded by inserting a size 15 K-file (Mani) until it became visible at the apical foramen, then reducing 1 mm from that length. Canal shaping was performed using Zen Flex rotary instruments, progressing to a master apical size of 25 with a 0.06 taper via the crown-down technique.[42]

During instrumentation, canals were irrigated with 3 mL of 5.25% NaOCl after each file, delivered through a 27-gauge Monoject needle. After shaping, canals were treated with 17% EDTA to eliminate the smear layer, followed by a final rinse with 10 mL of distilled water, and then dried using paper points.[43]

The samples were divided into two main groups for evaluation of different properties. **Group 1** was designated for assessing the remineralizing potential of the sealer and consisted of four subgroups: **Group 1A,** which involved untreated decoronated teeth; **Group 1B**, which involved Bio-C sealer; **Group 1C**, which involved Bio-C sealer combined with silver diamine fluoride; and **Group 1D**, which involved Bio-C sealer combined with propolis.

Group 2 focused on evaluating the fracture resistance of teeth, and was subdivided into four groups: **Group 2A**, which consisted of untreated teeth; **Group 2B**, which involved Bio-C sealer; **Group 2C**, which involved Bio-C sealer combined with silver diamine fluoride; and **Group 2D**, which involved Bio-C sealer combined with propolis.

Bio-C sealer was mixed with silver diamine fluoride for Group 1B and Group 2C, and the samples were obturated using a 25, 6% single-cone technique. For Group 1C and Group 2D, Bio-

C sealer was combined with propolis, and the samples were obturated with a 25, 6% single-cone technique. Group 1A and Group 2B were obturated with Bio-C sealer alone, utilizing a 25, 6% single-cone obturation method. Group 2A was left untreated and only decoronated. Periapical radiographs were obtained in both mesiodistal and buccolingual directions to verify complete canal obturation. Subsequently, 1 mm of the coronal portion of the filling material was removed, and the access cavities were sealed coronally using a temporary restorative material.[43]

To ensure the sealers fully set, all samples were stored at 100% humidity and 37°C for 14 days..[44]

FIGURE 22 : DECORONATION OF SAMPLE

Preparation of propolis :

Propolis was kept at –20°C. After freezing, the propolis was broken into smaller pieces to aid in the removal of any debris. The frozen propolis was then ground into a fine powder using an

electric mill. A total of 30 g of powdered propolis was placed in an amber coloured jar with a stopper and soaked in 70 mL of 70% ethanol at room temperature.[45]

FIGURE 23: WEIGHTING OF PROPOLIS

FIGURE 24 : PROPOLIS KEPT IN ETHANOL INSIDE AMBER COLOURED BOTTLE

The jar was kept in a dark place, with the mixture being stirred twice daily for approximately 15 days. The mixture was then subjected to centrifugation at 5000 rpm for 10 minutes, after which the product was carefully collected and subsequently filtered using Whatman No. 1 filter paper. [45]

FIGURE 25: FILTERATION OF PROPOLIS

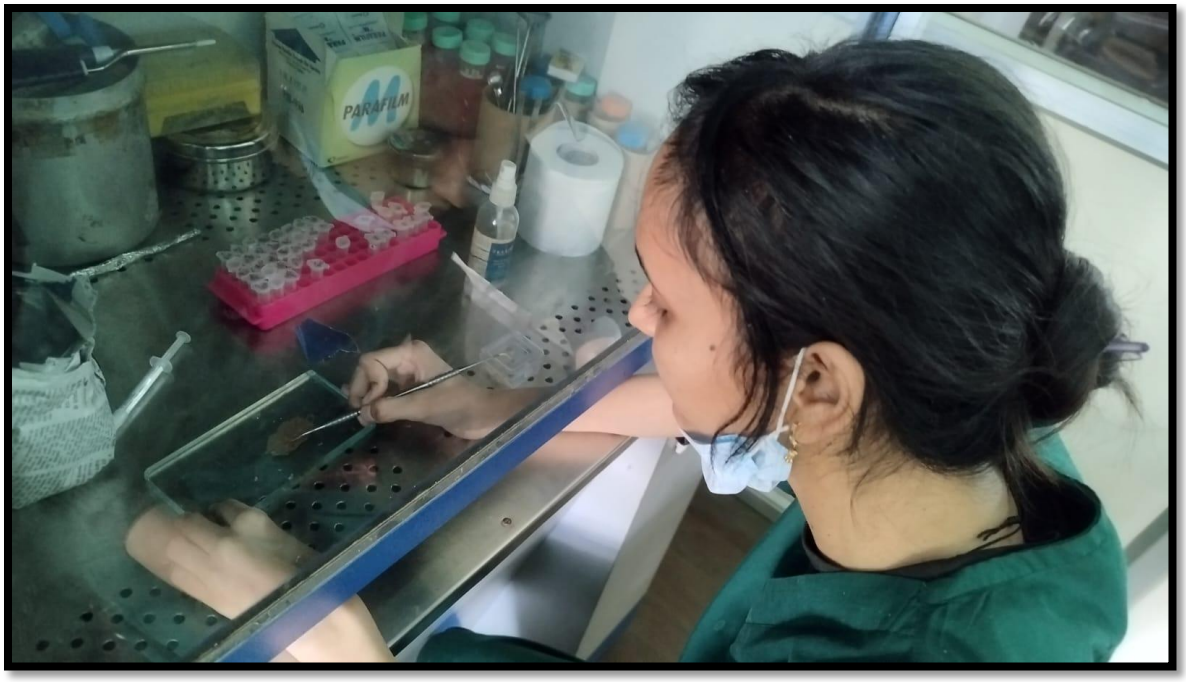


FIGURE 26: MIXING OF PROPOLIS WITH BIO C SEALER

The obtained extract was dried in a vacuum oven at 40°C under reduced pressure (500 mbar Hg). The resulting dried propolis was stored at –20°C for future analysis. [45]

SAMPLE PREPARATION FOR SCANNING ELECTRON MICROSCOPY

Transverse sections were made of each samples using diamond disc. After 21 days, all root dentin specimens were retrieved from the solutions to assess the potential regeneration of minerals on the demineralized dentin surface. The dentin samples were kept in ultrasonic cleaner for 10 min to remove all the debris produced by the cutting. [46]

The specimens were subsequently immersed in 1% glutaraldehyde in PBS for 4 hours at 4°C. After rinsing with PBS, they underwent a series of graded ethanol dehydrations, followed by a final rinse with 100% hexamethyldisilazane.[46]

Sample preparation provides the better resolution images. Generally, metal samples do not

require any preparation as it conducts the electricity which bombards the electrons to get images. But non-metal samples require sputter coat which made of conductive material most commonly silver. An electric field and argon gas are used to acquire the silver. Positively charged ions are produced when the argon's electron is knocked out by the electric field. The negatively charged gold foil is subsequently drawn to these positive ions. The argon ions release gold atoms when they land on the silver, coating the item with a thin layer of conductive material. Generally, preparation of samples involves the removal of water, because, if water present in the sample becomes vapour that interferes the electron beam that leads to reduced image clarity.[47] In this study, silver sputter coat of 300Å used for conduction of electrons. .

FIGURE 27: SILVER SPUTTERING

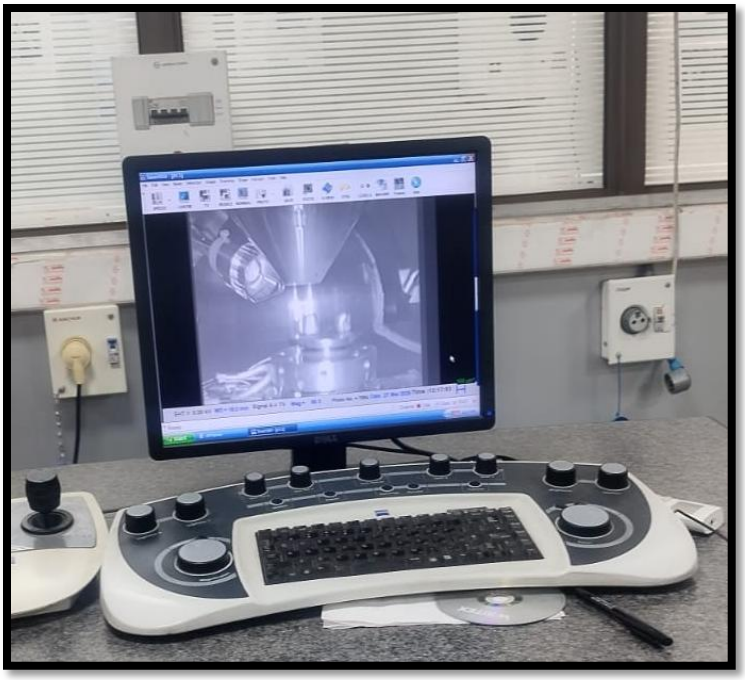


FIGURE 28 : CAMERA PICTURE OF THE INSIDE OF ELECTRON MICROSCOPE WHILE IN FUNCTION

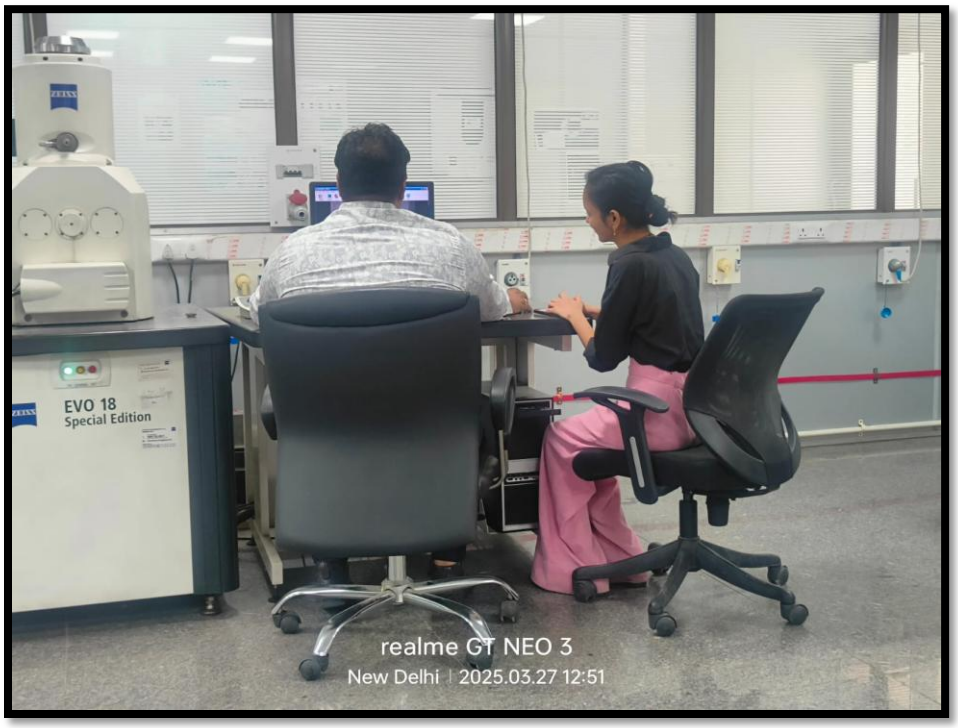


FIGURE 29: SEM ANALYSIS DONE AT IIT DELHI

Working of scanning electron microscope

Initially, the thermionic gun located on the top of SEM device having the filament which gets heated till electron gets streamed away and passes through the vacuum chamber, where the lenses were placed, because the electrons should not obstruct when it passes through the microscope. [49] The electrons are directed towards the specimen by lenses. Increasing the number of electrons, increases the magnification power of microscope. When the incident electron beam strikes the specimen, it generates X-rays and releases three types of electrons: primary backscattered electrons, secondary electrons, and Auger electrons.[50] From this, microscope utilises only primary backscattered electrons and secondary electrons. The rebounded electrons were recorded by the electron recorder and translated to screen which shows three-dimensional image.[51]

In this study, monochrome Scanning Electron Microscope (Evo 18 special edition) was used.

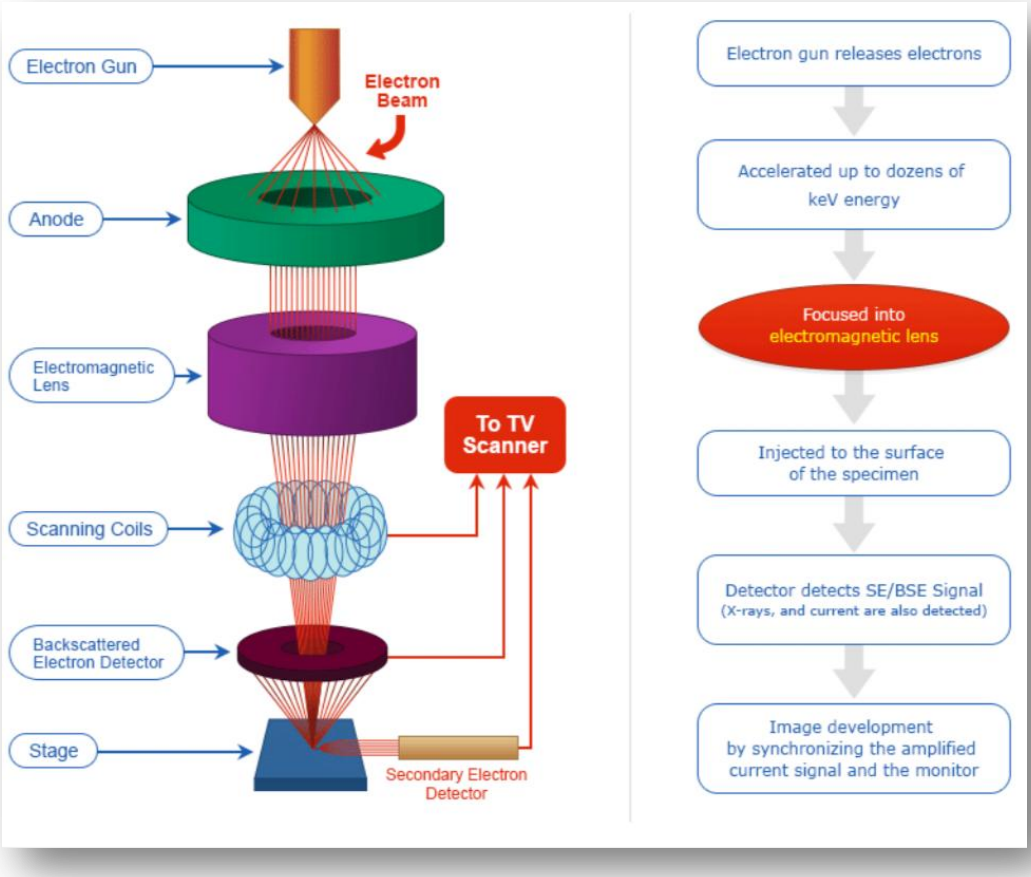


FIGURE 30 : DIAGRAMMATIC REPRESENTATION OF SEM WORKING

SAMPLE PREPARATION FOR FRACTURE RESISTANCE

A layer of wax material, approximately 0.2–0.3 mm thick, was applied to the apical 5 mm of each root to simulate the periodontal membrane. The specimens were then vertically positioned and embedded in acrylic cylinders measuring 15 mm in height and 10 mm in diameter, with 5 mm of root encased. Once the acrylic resin began to polymerize, the roots were carefully removed from the resin, and the wax coating was eliminated.[52] The root surfaces were coated by a thin layer of polyvinylsiloxane material and then reverted into the acrylic .[53] Fracture resistance was tested using a universal testing machine “Zwick Roell, Germany Static UTM Z010”. The samples were placed on the lower plate of the instrument. The upper plate consists of Compression platen with diameter 136mm. Compressive load was applied to the sample by compression platen at a crosshead speed of 1 mm/min until fracture. The fracture load was measured in Newtons (N). [54]

FIGURE 31: PROPOLIS ADDED TO BIOCERAMIC SEALER

FIGURE 32 : BIOCERAMIC SEALER

FIGURE 33: BIOCERAMIC SEALER WITH SILVER DIAMINE FLUORIDE

FIGURE 34: UNTREATED DE CORONATED TEETH

FIGURE 35: PLACEMENT OF SAMPLE UNDER COMPRESSION PLATE IN UTM

STATISTICAL ANALYSIS

The data for the present study was entered in the Microsoft Excel 2007 and analyzed using the SPSS statistical software 23.0 Version. The descriptive statistics included mean, standard deviation .The inter group comparison was done using One Way ANOVA to find the difference between groups. The level of the significance for the present study was fixed at 5%. The Shapiro–Wilk test was used to investigate the distribution of the data and Levene's test to explore the homogeneity of the variables.

$$\overline{X} = \frac{\Sigma X}{N}$$

Where:

$\overline{X}$ = the data set mean

$\sum$ = the sum of

X = the scores in the distribution

N = the number of scores in the distribution

Range

$$range = X_{highest} - X_{lowest}$$

Where:

$X_{highest}$ = largest score

X_{lowest} = smallest score

Variance

$$SD^2 = \frac{\Sigma(X - \overline{X})^2}{N}$$

The simplified variance formula

$$SD^2 = \frac{\Sigma X^2 - \frac{(\Sigma X)^2}{N}}{N}$$

Where:

SD2 = the variance

$\sum$ = the sum of

X = the obtained score

$\overline{X}$ = the mean score of the data

N = the number of scores

Standard Deviation (N)

$$SD = \sqrt{\frac{\Sigma(X - \overline{X})^2}{N}}$$

The simplified standard deviation formula

$$SD = \sqrt{\frac{\Sigma X^2 - \frac{(\Sigma X)^2}{N}}{N}}$$

Where:

SD = the standard deviation

$\sum$ = the sum of

X = the obtained score

$\overline{X}$ = the mean score of the data

N = the number of scores

Shapiro Wilk Test

The null-hypothesis of this test is that the population is normally distributed. Thus, if the p value is less than the chosen alpha level, then the null hypothesis is rejected and there is evidence that the data tested are not normally distributed. On the other hand, if the p value is greater than the chosen alpha level, then the null hypothesis (that the data came from a normally distributed population) can not be rejected (e.g., for an alpha level of .05, a data set with a p value of less than .05 rejects the null hypothesis that the data are from a normally distributed population – consequently, a data set with a p value more than the .05 alpha value fails to reject the null hypothesis that the data is from a normally distributed population).Like most statistical significance tests, if the sample size is sufficiently large this test may detect even trivial departures from the null hypothesis (i.e., although there may be some statistically significant effect, it may be too small to be of any practical significance); thus, additional investigation of the effect size is typically advisable, e.g., a Q–Q plot in this case.

One Way ANOVA

The formula for the one-way **ANOVA** *F*-test statistic is

$$F = \frac{\text{between-group variability}}{\text{within-group variability}}.$$

The between-group variability" is

$$\sum_{i=1}^{K} n_i (\bar{Y}_{i\cdot} - \bar{Y})^2 / (K-1)$$

where Y_i denotes the sample mean in the i^{th} group, n_i is the number of observations in the i^{th} group, $\bar{Y}$ denotes the overall mean of the data, and K denotes the number of groups.

The "within-group variability" is

$$\sum_{i=1}^{K}\sum_{j=1}^{n_i}(Y_{ij}-\bar{Y}_{i\cdot})^2/(N-K),$$

where Y_{ij} is the j^{th} observation in the i^{th} out of K groups and N is the overall sample size.

RESULTS

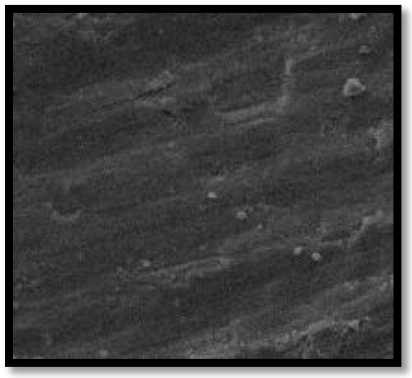


FIGURE 36:UNOBTURATED TREATED TEETH

FIGURE 37 :BIO C SEALER

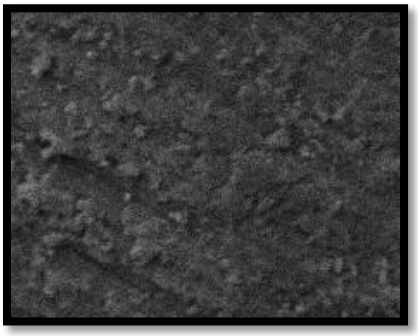


FIGURE 38: BIO C SEALER + SDF

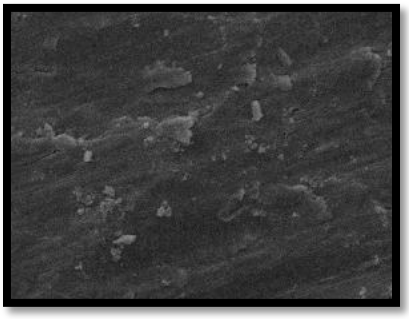


FIGURE 39: BIO C SEALER + PROPOLIS

The surfaces of unobturated teeth exhibited minimal crystal presence, likely due to dentin demineralization. The highest quantity of crystal deposition was observed in the group treated with silver diamine fluoride combined with Bio-C sealer, followed by the Bio-C sealer alone. The least crystal formation was noted in the group treated with propolis and Bio-C sealer.

Sr no	GROUP 2A	GROUP 2B [Bio C Sealer]	GROUP2C [Bio C + SDF]	GROUP 2D [Bio C + Propolis]
1	1493	975	1098	973
2	937	948	1230	593
3	1237	1052	987	1017
4	1402	988	990	773
5	1320	909	1106	693
6	1023	1032	877	1297
7	939	890	1038	895
8	1372	945	1178	990
9	1039	1021	887	1311
10	1037	866	798	731
11	960	936	901	670
12	1373	1003	912	1123
13	1462	923	1004	1074
14	1055	922	986	779
15	996	1072	846	1206
16	1873	921	1049	903
17	976	864	901	608

TABLE 1: RESULT FOR FRACTURE RESISTENCE

The highest mean fracture resistance was observed in the **normal group** (1205.50 ± 263.93), indicating that untreated teeth possess the greatest structural integrity. Among the treated groups, teeth filled with **Bio-C sealer combined with silver diamine fluoride (SDF)** demonstrated higher fracture resistance (987.53 ± 119.08) compared to those treated with **Bio-C sealer alone** (956.88 ± 62.97) and **Bio-C sealer**

with propolis (919.76 ± 231.20). The **Bio-C + propolis group** exhibited the lowest mean fracture resistance along with the highest variability, suggesting a less consistent reinforcing effect. These findings imply that the addition of SDF may improve the fracture resistance of teeth treated with Bio-C sealer.

TABLE 2: MEAN FRACTURE RESISTANCE OF THE GROUPS

Group	**N**	**Mean**	**Std. Deviation**	**Std. Error**	**95% CI Lower**	**95% CI Upper**	**Minimum**	**Maximum**
Normal	17	1205.500	263.926	64.012	1069.831	1341.228	937.000	1873.000
bio c sealer	17	956.880	62.967	15.272	924.508	989.257	864.000	1072.000
bio c + SDF	17	987.530	119.077	28.880	926.306	1048.753	798.000	1230.000
bio c + propolis	17	919.760	231.203	56.075	800.891	1038.638	593.000	1311.000

TABLE 3 : ONE WAY ANOVA COMPARISON OF FRACTURE RESISTANCE

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	841159.338	3	280386.446	7.940	0.001(Sig)
Within Groups	2260097.294	64	35314.020		
Total	3101256.632	67			

The descriptive statistics for the four groups show notable differences in the measured values. **Group 2A** had the highest mean value at **1205.5 ± 263.93**, ranging from 937 to 1873, indicating the greatest variability and upper range among all groups. **Group 2B** had a lower mean of **956.88 ± 62.97**, with a tighter range (864 to 1072), suggesting more consistency within this group. **Group 2C** reported a mean of **987.53 ± 119.08**, which is slightly higher than Group 2 but with a broader spread (798 to 1230). **Group 2D** had the lowest mean at **919.76 ± 231.20**, and a wide range from 593 to 1311, reflecting substantial variability.

The results of the one-way ANOVA revealed a statistically significant difference in fracture resistance among the four groups ($F(3, 64) = 7.940$, $p = 0.001$). This indicates that the mean fracture resistance was not equal across the groups, and at least one group demonstrated a significantly different resistance compared to the others. The between-group variation (Sum of Squares = 841,159.338) was substantial relative to the within-group variation (Sum of Squares = 2,260,097.294), confirming that group membership had a significant effect on the fracture resistance values.

GRAPH 1 : COMPARISM OF HIGHEST VALUE FOR FRACTURE RESISTANCE OF ALL THE GROUPS

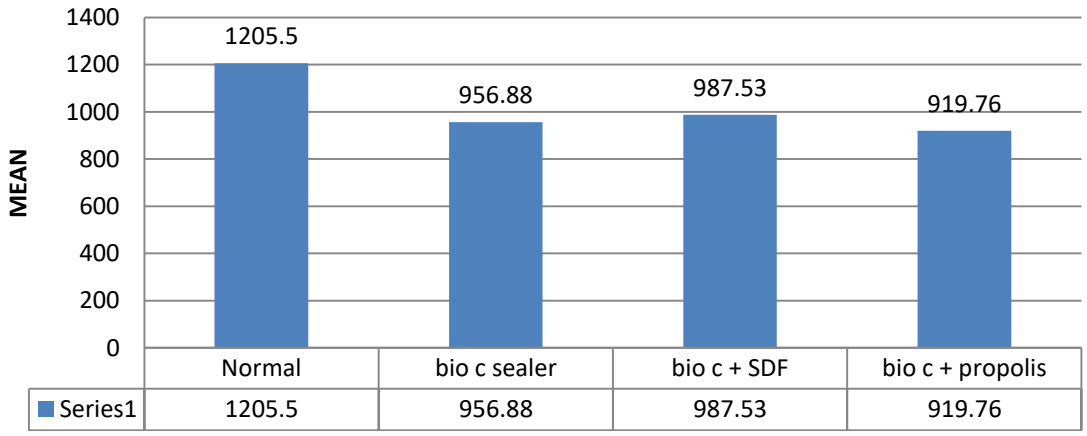
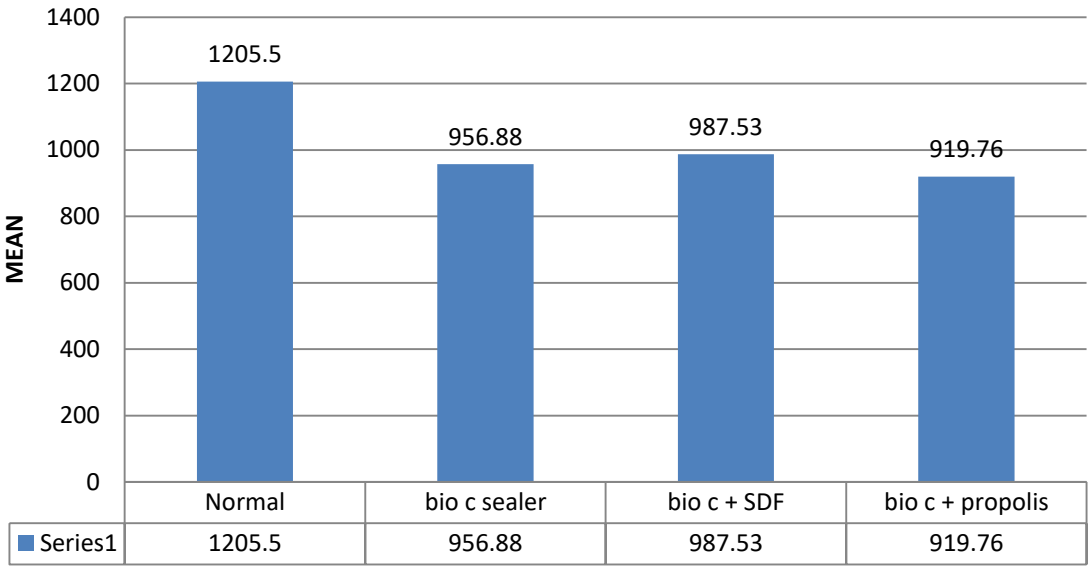


TABLE 4 : POST HOC INTERGROUP COMPARISON OF FRACTURE RESISTANCE BETWEEN THE GROUPS

Group (I)	**Group (J)**	**Mean Difference (I–J)**	**Std. Error**	**p-value**	**Significance**
Normal	Bio C Sealer	248.647	64.456	0.001	Significant
Normal	Bio C + SDF	218.000	64.456	0.001	Significant
Normal	Bio C + Propolis	285.765	64.456	0.001	Significant
Bio C Sealer	Bio C + SDF	-30.647	64.456	0.636	Not Significant
Bio C Sealer	Bio C + Propolis	37.118	64.456	0.567	Not Significant
Bio C + SDF	Bio C + Propolis	67.765	64.456	0.297	Not Significant

The post hoc analysis of fracture resistance revealed statistically significant differences between the normal group and all other experimental groups. Specifically, the normal group exhibited significantly higher fracture resistance compared to the Bio C Sealer group (mean difference = 248.647, $p = 0.001$), the Bio C + SDF group (mean difference = 218.000, $p = 0.001$), and the Bio C + Propolis group (mean difference = 285.765, $p = 0.001$). These findings indicate that the introduction of Bio C Sealer, with or without additives like SDF or propolis, results in a significant reduction in fracture resistance when compared to untreated controls. However, no statistically significant differences were found among the three experimental groups themselves—Bio C Sealer vs. Bio C + SDF ($p = 0.636$), Bio C Sealer vs. Bio C + Propolis ($p = 0.567$), and Bio C + SDF vs. Bio C + Propolis ($p = 0.297$)—suggesting that the addition of SDF or propolis to Bio C Sealer does not significantly alter its effect on fracture resistance.

GRAPH 2 : COMPARISM OF MEAN VALUE FOR FRACTURE RESISTANCE OF ALL GROUPS



DISCUSSION

Extensive removal of tooth material during root canal preparation and applying excessive pressure during obturation can weaken endodontically treated teeth by reducing their fracture resistance [55]. Additionally, irrigating solutions may lead to dentin dehydration, lowering its elastic modulus and flexural strength, thereby increasing the risk of root fracture [56].

Root canal filling materials and sealers play a vital role in reinforcing endodontically treated teeth. Therefore, it is essential to choose obturation materials that can enhance the strength of the chemically and mechanically compromised root structure [57]..

Standardizing human teeth for fracture resistance studies presents a challenge due to anatomical variations, differences in age, and timing of extraction [58, 59]. To minimize these variables, our study standardized the roots based on preparation size, root width, and length. Previous research suggests that shaping root canals into a round cross-section helps evenly distribute stress during obturation, thereby reducing the risk of fractures [60]. Accordingly, rotary files were used for canal preparation.

A UTM was used to measure fracture resistance, a method employed in various studies [61,62]. In our setup, vertical forces were employed along the longitudinal axis of teeth to ensure that the load was fully transferred to the root structure [61,62].

The smear layer, composed of inorganic debris, necrotic pulp remnants, bacteria, and blood components, can hinder the penetration of sealers into dentinal tubules, limiting their ability to reinforce the root structure [63]. Therefore, its removal is recommended [64]. In this study, EDTA was used to eliminate the smear layer due to its low surface tension and effective penetration into dentinal tubules, dissolving debris to a depth of approximately 2.5 to 4 µm [65,66]. This improves sealer adhesion and adaptation to the canal walls [66, 67]. In the final step, distilled water was applied to eliminate and neutralize any leftover irrigant traces.[67]

This study is intended to compare the fracture resistance of untreated teeth with teeth treated using Bio-C Sealer alone, Bio-C Sealer combined with silver diamine fluoride (SDF), and Bio-C

Sealer combined with propolis. The results revealed that untreated teeth exhibited the highest fracture resistance, followed by Bio-C + SDF, Bio-C alone, and finally Bio-C + propolis.

The results of study displayedd that the untreated group (Group 2A) had a mean fracture resistance of 1205.5 N, which was significantly more than the experimental groups treated with bioceramic sealer. This suggests that untreated teeth might exhibit better mechanical properties, specifically in terms of fracture resistance, when compared to those treated with a bioceramic sealer.[68]

The reason untreated teeth demonstrate better fracture resistance may be attributed to the process of endodontic treatment, which inherently weakens the tooth structure. During root canal therapy, cleaning and shaping involve the removal of dentin to create space for the root canal filling. This reduction in dentin directly compromises the tooth's structural integrity, leaving it more vulnerable to fracture.[69] Additionally, the prolonged contact of root canal irrigants with dentin can affect the mechanical properties of the tooth. The use of irrigants typically removes organic components from the dentin, which weakens its overall strength and resilience.[70]

Moreover, the application of excessive force during the filling procedure can also weaken the tooth. Techniques like lateral compaction, commonly used during root canal therapy, may introduce stresses into the tooth, especially when spreaders are applied to compact the filling material. These stresses can further reduce the tooth’s ability to withstand fracture.[71]

The bioceramic sealer group exhibited a mean fracture resistance of 956.88 N, which was lower than that of the untreated teeth group. This reduction in fracture resistance, despite the favorable properties of bioceramic materials, can be attributed to several factors related to the material’s bonding mechanism, the nature of the root canal treatment process, and its interaction with the tooth structure.[72]

Bioceramic-based sealers are known for their excellent sealing ability and biocompatibility. Zhang et al. [73] have suggested that the bonding of bioceramic sealers to root dentin is primarily a mechanical interlocking bond, where the sealer molecules disperse into the dentinal tubules, creating a physical bond with the tooth structure. While this interaction can enhance the seal within the canal, it may not significantly contribute to strengthening the tooth's overall

mechanical properties. The permeation of the bioceramic material into the dentin tubules may result in some mineralization of the dentin, as noted by Han and Okiji [74], which forms a mineral infiltration zone. This mineralization could lead to the denaturation of collagen fibers, but the resulting mechanical properties may still not provide enough reinforcement to overcome the structural weakening caused by the cleaning and shaping process.[74]

Additionally, while bioceramic sealers may react with dentinal minerals to form hydroxyapatite along the mineral infiltration zone, as suggested by some studies [75], this reaction is more focused on enhancing the sealing efficiency and biocompatibility of the material rather than improving the fracture resistance of the treated tooth. The lack of a substantial increase in fracture resistance after bioceramic sealer application could therefore be due to the limited contribution of the sealer to reinforcing the remaining dentin.[61]

In contrast, untreated teeth retain their natural dentin structure, which provides inherent strength and resistance to fracture. Even though the root canal procedures, including cleaning and shaping, reduce dentin thickness and may affect dentin properties, the untreated group still maintains more of the tooth's original mechanical properties compared to teeth treated with bioceramic sealers.

The lower fracture resistance observed in the bioceramic sealer group may also be a result of treatment techniques, such as the root canal preparation and irrigation processes, which can further weaken the tooth structure. Bioceramic sealers may fill the canal effectively, but they may not have sufficient mechanical reinforcement to compensate for the weakening effects of these procedures.[76]

Overall, while bioceramic sealers provide excellent sealing and biological benefits, their ability to improve fracture resistance is limited, suggesting the need for further research into how these materials can be optimized for strengthening treated teeth, either by combining them with other materials or through innovative treatment techniques[77]

Among the treated groups, Bio-C Sealer combined with SDF (987.5 N) showed marginally improved resistance compared to Bio-C Sealer alone (956.9 N). This may be attributed to the known ability of SDF to enhance dentin hardness, inhibit collagen degradation, and promote

remineralization.[78] Silver ions released from SDF interact with dentin proteins, forming silver-protein conjugates that protect the collagen matrix from enzymatic breakdown. Additionally, the deposition of calcium fluoride and other mineral products aids in forming a protective layer on the dentin surface, which may contribute to increased mechanical integrity.[79]

SDF is also known to occlude dentinal tubules and reduce dentin permeability, which may help stabilize the dentin–sealer interface and reduce microleakage or crack propagation under stress.[80] The presence of fluoride in SDF supports remineralization of demineralized dentin, potentially reinforcing areas weakened by endodontic instrumentation. Moreover, the antimicrobial properties of SDF may reduce residual bacterial activity at the interface, indirectly contributing to structural stability by preserving dentin quality over time.[81]

While the increase in fracture resistance was not statistically significant, the observed trend suggests that SDF has a beneficial, albeit limited, reinforcing effect when used in conjunction with Bio-C Sealer. These findings support the hypothesis that adjunctive treatments like SDF can modestly improve the biomechanical performance of root-filled teeth, particularly when structural preservation is a clinical concern. Future studies with extensive observation periods and more sample sizes could help clarify the long-term mechanical benefits of combining SDF with bioceramic sealers in endodontic therapy.

In contrast, the Bio-C Sealer with propolis group (919.8 N) demonstrated the lowest fracture resistance among the experimental groups. Although propolis is well known for its strong antimicrobial, anti-inflammatory, and healing-promoting properties, its mechanical compatibility with endodontic sealers remains unclear. The lower fracture resistance observed may be due to chemical or physical interactions between propolis constituents—such as flavonoids, aromatic acids, and waxes—and the Bio-C Sealer matrix. These interactions could interfere with the sealer's setting reaction or compromise its adhesion to dentin, ultimately weakening the structural integrity of the restored root.[82]

Supporting this, histological and sealing ability evaluations from prior studies suggest that propolis-based sealers may exhibit poor penetration and adaptation within the dentinal tubules, possibly due to the viscosity and adhesive nature of its resinous components[83]. These physical

properties may prevent deep infiltration into micro-irregularities, a key mechanism behind the mechanical interlocking bond that bioceramic sealers rely on to reinforce the tooth structure. Furthermore, studies using dye-extraction and microleakage tests reported macroscopic leakage and weak sealing capacity associated with propolis-containing formulations, which were also prone to staining and irregular application. Such poor marginal adaptation could contribute to stress concentration and crack propagation under vertical load, thereby reducing overall fracture resistance.[84]

Therefore, while propolis may offer promising biological benefits, its mechanical integration with bioceramic sealers like Bio-C appears suboptimal under current formulations and application methods. Further research is warranted to optimize its delivery, enhance its bonding potential, and assess long-term performance if it is to be considered a viable adjunct in endodontic treatments.

The Bio-C sealer exhibited substantial crystal deposition, which can be linked to its chemical composition. SEM-EDX analysis showed high levels of calcium, oxygen, and silicon in Bio-C sealer, elements known to promote bioactivity and biomineralization, facilitating interaction with apical tissues, as demonstrated by Ana et al. in their comparative study on the cytocompatibility and mineralization potential of Bio-Ceramic Sealer [85]. These findings align with previous research showing that sealers containing calcium silicates in similar amounts exhibit significant bioactive properties and encourage mineral deposition. Furthermore, the use of zirconium oxide as a radiopacifier in Bio-C sealer offers advantages over traditional bismuth oxide, reducing heavy metal content while maintaining adequate physicochemical properties and radiopacity according to ISO 6876/2001 standards [86,87]. Collectively, these factors likely contribute to the enhanced biomineralization observed with Bio-C sealer in this study.

The highest amount of crystal deposition observed in the group treated with silver diamine fluoride (SDF) combined with Bio-C sealer can be attributed to the multifaceted effects of SDF on dentin. SDF is known to enhance dentin hardness, inhibit collagen degradation, and promote remineralization [78]. Silver ions released from SDF interact with dentin proteins to form silver-protein conjugates that protect the collagen matrix from enzymatic breakdown. Additionally, the deposition of calcium fluoride and other mineral products creates a protective layer on the dentin

surface, contributing to increased mechanical integrity [79]. SDF also occludes dentinal tubules and reduces dentin permeability, which may help stabilize the dentin–sealer interface and reduce microleakage or crack propagation under stress [80]. The fluoride component supports remineralization of demineralized dentin, potentially reinforcing areas weakened by endodontic instrumentation. Furthermore, the antimicrobial properties of SDF reduce residual bacterial activity at the interface, indirectly preserving dentin quality and contributing to long-term structural stability [81]. When combined with the bioactive properties of Bio-C sealer, these effects synergistically promote enhanced crystal deposition and dentin reinforcement, supporting improved clinical outcomes.

Although propolis is well known for its antimicrobial, anti-inflammatory, and healing-promoting properties, it does not possess significant remineralization potential on its own. Some studies have shown that propolis can promote increased saliva production when combined with gum, but this indirect effect does not translate into enhanced mineral deposition on dentin surfaces. Consequently, no notable difference in remineralization was observed compared to the Bio-C sealer alone.[88] Additionally, chemical or physical interactions between propolis constituents—such as flavonoids, aromatic acids, and waxes—and the Bio-C sealer matrix could interfere with the sealer's setting reaction or its adhesion to dentin, potentially compromising the structural integrity of the restored root.[77]

CONCLUSION

This study evaluated the fracture resistance and remineralization potential of teeth treated with Bio-C sealer alone and in combination with silver diamine fluoride (SDF) or propolis. The findings demonstrated that untreated teeth exhibited the highest fracture resistance, highlighting the inherent strength of natural tooth structure. Among the treated groups, the addition of SDF to Bio-C sealer resulted in marginally improved fracture resistance and the highest level of crystal deposition, likely due to its remineralizing and dentin-stabilizing properties. In contrast, the Bio-C + propolis group showed the lowest fracture resistance and minimal crystal formation, indicating potential incompatibility between propolis components and the Bio-C sealer matrix.

Although none of the experimental treatments fully restored the mechanical strength of untreated teeth, the combination of Bio-C sealer with SDF showed promising trends in enhancing dentin reinforcement and biomineralization. These results suggest that while bioceramic sealers offer valuable biological and sealing properties, their mechanical performance can be modestly improved through adjunctive treatments like SDF. However, propolis, despite its biological benefits, may not be suitable for enhancing the mechanical properties of endodontically treated teeth without further formulation optimization. Future research should explore long-term clinical outcomes and focus on improving the integration and performance of these biomaterials to better support the structural integrity of root-filled teeth.

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ANNEXURES

ANNEXURE I : ETHICAL COMMITTEE APPROVAL FORM

SANTOSH
Deemed to be University
(Established u/s 3 of the UGC Act, 1956)

F. No. SU/2023/2480[9] Dated: 26.09.2023

Subject: Grant of Ethical Clearance for Thesis Protocol Topic "A COMPARATIVE EVALUATION OF ADDITION OF PROPOLIS OR SILVER DIAMINE FLUORIDE TO BIO-C SEALER ON REMINERALIZATION AND FRACTURE RESISTENCE OF RADICULAR DENTIN USING AN IN-VITRO LABORATORY MODAL", submitted by **Dr. PATIL TEJAL HEMANT,** MDS student of Batch 2022-2023, Department of **CONSERVATIVE DENTISTRY & ENDODONTICS**.

*****

With reference to his/her request for grant of Ethical Clearance for the Thesis Protocol entitled "A COMPARATIVE EVALUATION OF ADDITION OF PROPOLIS OR SILVER DIAMINE FLUORIDE TO BIO-C SEALER ON REMINERALIZATION AND FRACTURE RESISTENCE OF RADICULAR DENTIN USING AN IN-VITRO LABORATORY MODAL", **Dr. PATIL TEJAL HEMANT** is informed that the Thesis Protocol submitted by him/her was considered by the **Screening Committee** of the Santosh Dental College & Hospital in its meetings held on 07.02.2023 & 08.02.2023. The recommendations of the **Screening Committee** were considered in detail by the Institutional **Ethics Committee** in its meeting held on **23.09.2023** and the same was **approved** by the **Ethics Committee**.

He /She is informed accordingly for further necessary action.

[DR. NARESH SHARMA]
REGISTRAR

SANTOSH "DEEMED TO BE UNIVERSITY" REGISTRAR GHAZIABAD, (U.P.) INDIA

Dr. PATIL TEJAL HEMANT
MDS student of batch 2022-2023
Department of CONSERVATIVE DENTISTRY & ENDODONTICS
Email: waytothp@gmail.com

Copy to:
1. The Vice Chancellor
2. The Dean, SDC&H
3. The Dean – Research
4. The Dean – Academics
5. The Director - IQAC
6. **Dr. Sumita Giri** (Guide)
7. HOD of **CONSERVATIVE DENTISTRY & ENDODONTICS**

ANNEXURE II: NOC – LAB FROM IIT DELHI FOR USING SCANNING ELECTRON MICROSCOPY

CRF Online Booking completed Message For :: SEM Inbox ×

CRF IITD <noreplycrf@iitd.ac.in> Thu, Mar 27, 12:42 PM

to me

Dear Tejal Patil,
Your Appointment has been completed with following details :
Application ID :: 207194
Instrument Name :: SEM
Booking Date time :: Mon 03-03-2025 01:27 PM
Appointment Date Time :: Thu 27-03-2025 12:00-01:00 PM
No. of Samples :: 2 Completed Out of 3
Remark of Compleation :: Done
CRF Account Balance Amount is Rs. -> :: 357275.8

Your Job as per the above details for the SEM has been Successfully Completed. Thank you for availing services of CRF.

Please provide your feedback by clicking on the link above. Your feedback is very important to improve CRF services. Your identity would be kept confidential.

Best Regards
SEM Central Facility
Ph:011-2659-6645
//
It's a system generated Email, do not reply.

CRF Online Booking completed Message For :: SEM Inbox ×

CRF IITD <noreplycrf@iitd.ac.in> Thu, Mar 27, 12:42 PM

to me

Dear Tejal Patil,
Your Appointment has been completed with following details :
Application ID :: 207195
Instrument Name :: SEM
Booking Date time :: Mon 03-03-2025 01:27 PM
Appointment Date Time :: Thu 27-03-2025 1:00 - 2:00 PM
No. of Samples :: 2 Completed Out of 3
Remark of Compleation :: Done
CRF Account Balance Amount is Rs. -> :: 357275.8

Your Job as per the above details for the SEM has been Successfully Completed. Thank you for availing services of CRF.

Please provide your feedback by clicking on the link above. Your feedback is very important to improve CRF services. Your identity would be kept confidential.

Best Regards
SEM Central Facility
Ph:011-2659-6645
//
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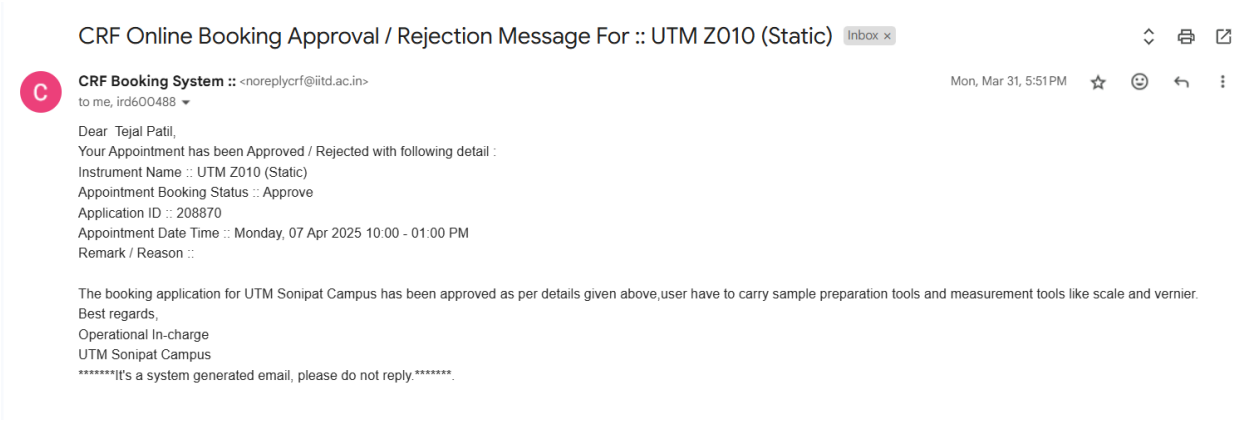
ANNEXURE III : NOC – LAB FROM IIT SONIPAT FOR UNIVERSAL TESTING MACHINE



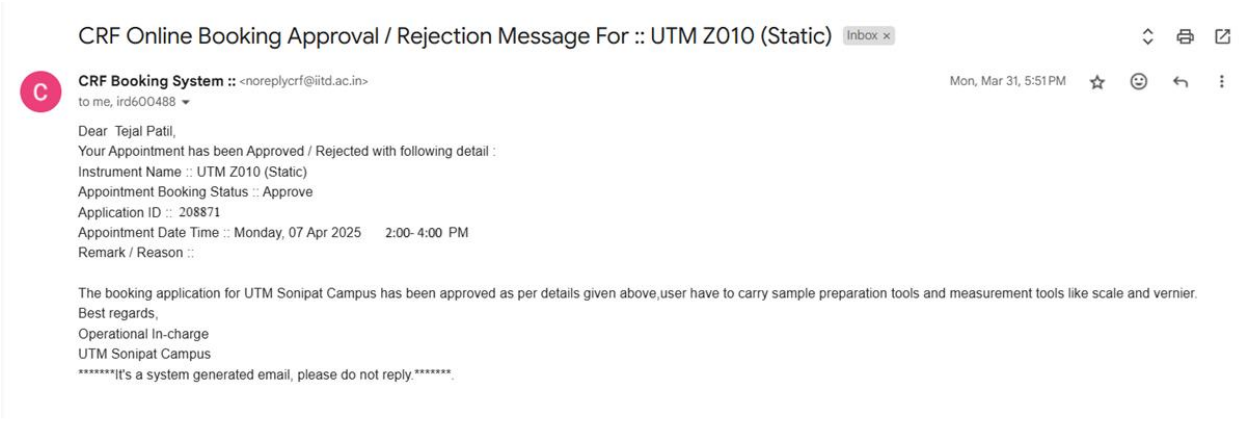
CRF Online Booking Approval / Rejection Message For :: UTM Z010 (Static) Inbox ×

CRF Booking System :: <noreplycrf@iitd.ac.in> Mon, Mar 31, 5:51 PM

to me, ird600488

Dear Tejal Patil,
Your Appointment has been Approved / Rejected with following detail :
Instrument Name :: UTM Z010 (Static)
Appointment Booking Status :: Approve
Application ID :: 208870
Appointment Date Time :: Monday, 07 Apr 2025 10:00 - 01:00 PM
Remark / Reason ::

The booking application for UTM Sonipat Campus has been approved as per details given above,user have to carry sample preparation tools and measurement tools like scale and vernier.
Best regards,
Operational In-charge
UTM Sonipat Campus
*******It's a system generated email, please do not reply.*******.



CRF Online Booking Approval / Rejection Message For :: UTM Z010 (Static) Inbox ×

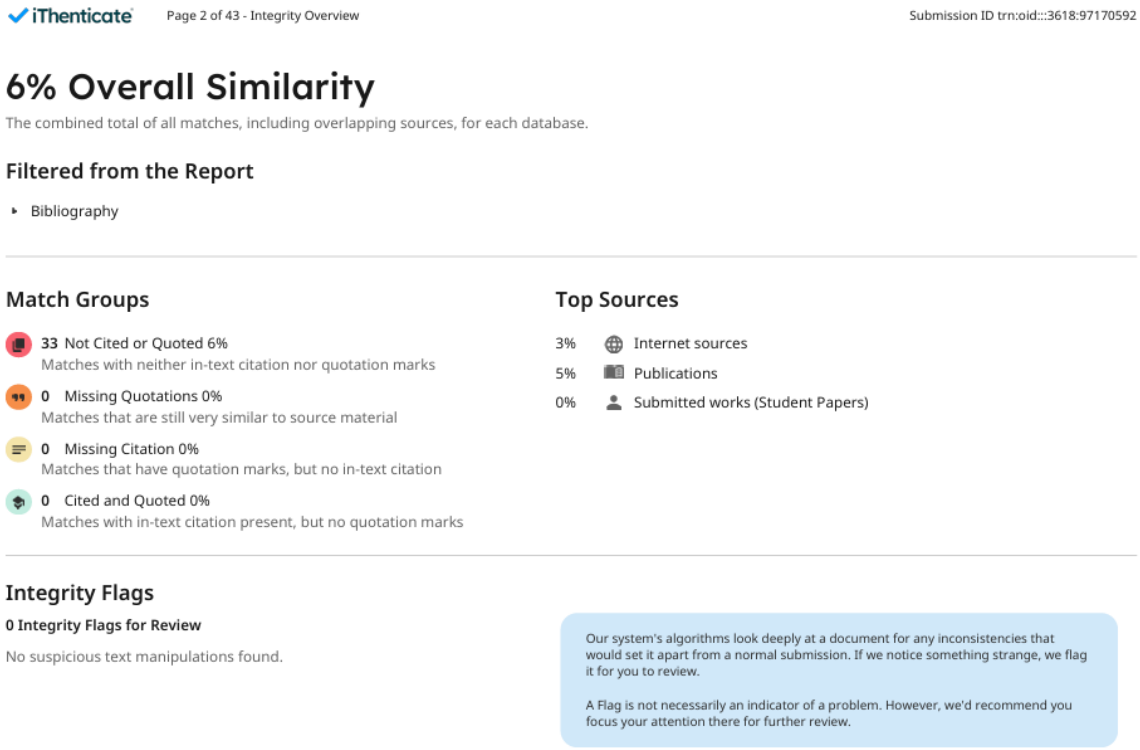
CRF Booking System :: <noreplycrf@iitd.ac.in> Mon, Mar 31, 5:51 PM

to me, ird600488

Dear Tejal Patil,
Your Appointment has been Approved / Rejected with following detail :
Instrument Name :: UTM Z010 (Static)
Appointment Booking Status :: Approve
Application ID :: 208871
Appointment Date Time :: Monday, 07 Apr 2025 2:00- 4:00 PM
Remark / Reason ::

The booking application for UTM Sonipat Campus has been approved as per details given above,user have to carry sample preparation tools and measurement tools like scale and vernier.
Best regards,
Operational In-charge
UTM Sonipat Campus
*******It's a system generated email, please do not reply.*******.

ANNEXURE IV: ANTI PLAGIARISM REPORT



iThenticate Page 2 of 43 - Integrity Overview Submission ID trn:oid:::3618:97170592

6% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Filtered from the Report

- Bibliography

Match Groups

- **33** Not Cited or Quoted 6%
  Matches with neither in-text citation nor quotation marks
- **0** Missing Quotations 0%
  Matches that are still very similar to source material
- **0** Missing Citation 0%
  Matches that have quotation marks, but no in-text citation
- **0** Cited and Quoted 0%
  Matches with in-text citation present, but no quotation marks

Top Sources

- 3% Internet sources
- 5% Publications
- 0% Submitted works (Student Papers)

Integrity Flags

0 Integrity Flags for Review

No suspicious text manipulations found.

Our system's algorithms look deeply at a document for any inconsistencies that would set it apart from a normal submission. If we notice something strange, we flag it for you to review.

A Flag is not necessarily an indicator of a problem. However, we'd recommend you focus your attention there for further review.